



**EAST WATERWAY OPERABLE UNIT
SUPPLEMENTAL REMEDIAL INVESTIGATION/
FEASIBILITY STUDY
QUALITY ASSURANCE PROJECT PLAN:
POREWATER STUDY
FINAL**

For submittal to:

The US Environmental Protection Agency
Region 10
Seattle, WA

July 2010

Prepared by:



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**EAST WATERWAY POREWATER STUDY
FINAL QUALITY ASSURANCE PROJECT PLAN**

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Table of Contents

Tables	v
Figures and Maps	v
Acronyms	v
1 Introduction	1
2 Project Management	1
2.1 PROJECT ORGANIZATION AND TEAM MEMBER RESPONSIBILITIES	1
2.1.1 Project management	3
2.1.2 Field coordination	4
2.1.3 Quality assurance/quality control	4
2.1.4 Laboratory project management	5
2.1.5 Data management	5
2.2 PROBLEM DEFINITION/BACKGROUND	6
2.2.1 Objective	6
2.2.2 Conceptual site model	6
2.2.3 Historical data	9
2.3 PROJECT/TASK DESCRIPTION AND SCHEDULE	13
2.4 QUALITY OBJECTIVE AND CRITERIA FOR CHEMICAL DATA	13
2.5 SPECIAL TRAINING/CERTIFICATION	14
2.6 DOCUMENTATION AND RECORDS	14
2.6.1 Field observations	14
2.6.2 Laboratory records	15
2.6.3 Data reduction	18
2.6.4 Data and analysis report	19
3 Data Generation and Acquisition	19
3.1 STUDY DESIGN	20
3.2 SAMPLING METHODS	20
3.2.1 Sample identification	21
3.2.2 Location positioning	21
3.2.3 Porewater sample collection	22
3.2.4 Field equipment	24
3.2.5 Decontamination procedures	25
3.2.6 Field-generated waste disposal	25
3.3 SAMPLE HANDLING AND CUSTODY	25
3.3.1 Sample handling procedures	25
3.3.2 Sample custody procedures	26
3.3.3 Shipping requirements and receipt	26
3.4 ANALYTICAL METHODS REQUIREMENTS	27
3.4.1 Analytical methods and laboratory sample handling	27
3.4.2 Data quality indicators	27

3.5	QUALITY ASSURANCE/QUALITY CONTROL	30
3.5.1	Field quality control samples	30
3.5.2	Chemical analyses	30
3.6	FIELD AND LABORATORY INSTRUMENT/EQUIPMENT TESTING, INSPECTION, AND MAINTENANCE	32
3.7	INSTRUMENT CALIBRATION AND FREQUENCY	32
3.8	INSPECTION/ ACCEPTANCE OF SUPPLIES AND CONSUMABLES	33
3.9	DATA MANAGEMENT	33
4	Assessment and Oversight	34
4.1	COMPLIANCE ASSESSMENTS AND RESPONSE ACTIONS	34
4.1.1	Compliance assessments	34
4.1.2	Response actions for field sampling	34
4.1.3	Corrective action for laboratory analyses	34
4.2	REPORTS TO MANAGEMENT	34
5	Data Validation and Usability	35
5.1	DATA VALIDATION	35
5.2	RECONCILIATION WITH DATA QUALITY OBJECTIVES	36
6	References	36

Appendix A. Health and Safety Plan

Appendix B. Field Forms

Appendix C. Risk-Based Analytical Concentration Goals for VOCs in Porewater

Tables

Table 2-1.	Groundwater monitoring events conducted adjacent to the East Waterway and summary of VOC results	11
Table 2-2.	Electronic data deliverable format for chemical data	17
Table 3-1.	Porewater sampling areas and rationale	20
Table 3-2.	Porewater sampling field equipment	24
Table 3-3.	Laboratory analytical methods and sample handling requirements	27
Table 3-4.	Summary of DQIs for laboratory analyses	28
Table 3-5.	Laboratory quality control sample analysis summary	31

Figures and Maps

Figure 2-1.	Project organization	2
Map 2-1.	Porewater sampling locations	7
Figure 2-2.	Conceptual site model of groundwater-surface water interaction	9
Figure 3-1.	Piezometer sampling set up	23

Acronyms

Acronym	Definition
%RSD	percent relative standard deviation
ARI	Analytical Resources, Inc.
BTEX	benzene, toluene, ethylbenzene, and xylene
CAS	Chemical Abstracts Service
CFR	Code of Federal Regulations
COC	chain of custody
DQI	data quality indicator
DQO	data quality objective
Ecology	Washington State Department of Ecology
EDD	electronic data deliverable
EPA	US Environmental Protection Agency
ERA	ecological risk assessment
EW	East Waterway
EWG	East Waterway Group
FC	field coordinator
FS	feasibility study

Acronym	Definition
GATX	GATX Terminals Corporation
GC/MS	gas chromatography/mass spectrometry
GPS	global positioning system
HAZWOPER	hazardous waste operations and emergency response
HSP	health and safety plan
ID	identification
LCL	lower control limit
LCS	laboratory control sample
MDL	method detection limit
MS	matrix spike
MSD	matrix spike duplicate
NAD83	North American Datum of 1983
NAVD88	North American Vertical Datum of 1988
NOEC	no-observed-effect concentration
OSHA	Occupational Safety and Health Administration
OU	operable unit
PM	project manager
PSEP	Puget Sound Estuary Program
QA/QC	quality assurance/quality control
QAPP	quality assurance project plan
RL	reporting limit
RPD	relative percent difference
SDG	sample delivery group
SRI	supplemental remedial investigation
T-25	Terminal 25
T-30	Terminal 30
T-104	Terminal 104
TIC	tentatively identified compound
TM	task manager
UCL	upper control limit
USCG	US Coast Guard
VOC	volatile organic compound
Windward	Windward Environmental LLC

1 Introduction

This quality assurance project plan (QAPP) describes the sampling design and quality assurance objectives and protocol for collecting sediment porewater samples in the East Waterway (EW). The porewater samples will be collected from intertidal locations that may be affected by groundwater from adjacent upland areas and will be analyzed for volatile organic compounds (VOCs). Details about project organization and management, field data collection methods, sample handling, laboratory analytical protocols, and data management and documentation are also provided. This QAPP was prepared in accordance with US Environmental Protection Agency (EPA) guidance (2002a).

Porewater data from this study will be used to support the ecological risk assessment (ERA) conducted as part of the supplemental remedial investigation (SRI) and feasibility study (FS) for the EW. VOCs are the chemicals of concern for porewater because other chemicals of interest will be assessed based on concentrations measured in sediment and benthic tissue to address risks to benthic invertebrates. VOCs are not strongly associated with either sediment or benthic tissues. This QAPP is organized as follows:

- ◆ Section 2 – Project Management
- ◆ Section 3 – Data Generation and Acquisition
- ◆ Section 4 – Assessment and Oversight
- ◆ Section 5 – Data Validation and Usability
- ◆ Section 6 – References

A health and safety plan (HSP) designed for the protection of onsite personnel from physical, chemical, and other hazards posed during field sampling activities is included as Appendix A. Field forms are included as Appendix B. Method detection limits (MDLs) and reporting limits (RLs) are compared to risk-based analytical concentration goals in Appendix C.

2 Project Management

This section describes the overall management of the project; identifies key personnel; and describes their responsibilities, including field coordination, quality assurance and quality control (QA/QC), laboratory management, and data management.

2.1 PROJECT ORGANIZATION AND TEAM MEMBER RESPONSIBILITIES

The East Waterway Group (EWG), which comprises the Port of Seattle, City of Seattle, and King County, as well as EPA will be involved in all aspects of this project,

including discussion, review, and approval of the QAPP and the interpretation of the investigation results. Windward Environmental LLC (Windward) will be responsible for the management and implementation of the effort described in this QAPP and coordination with EPA and the EWG. Figure 2-1 shows the overall project organization for the porewater study described in this QAPP.

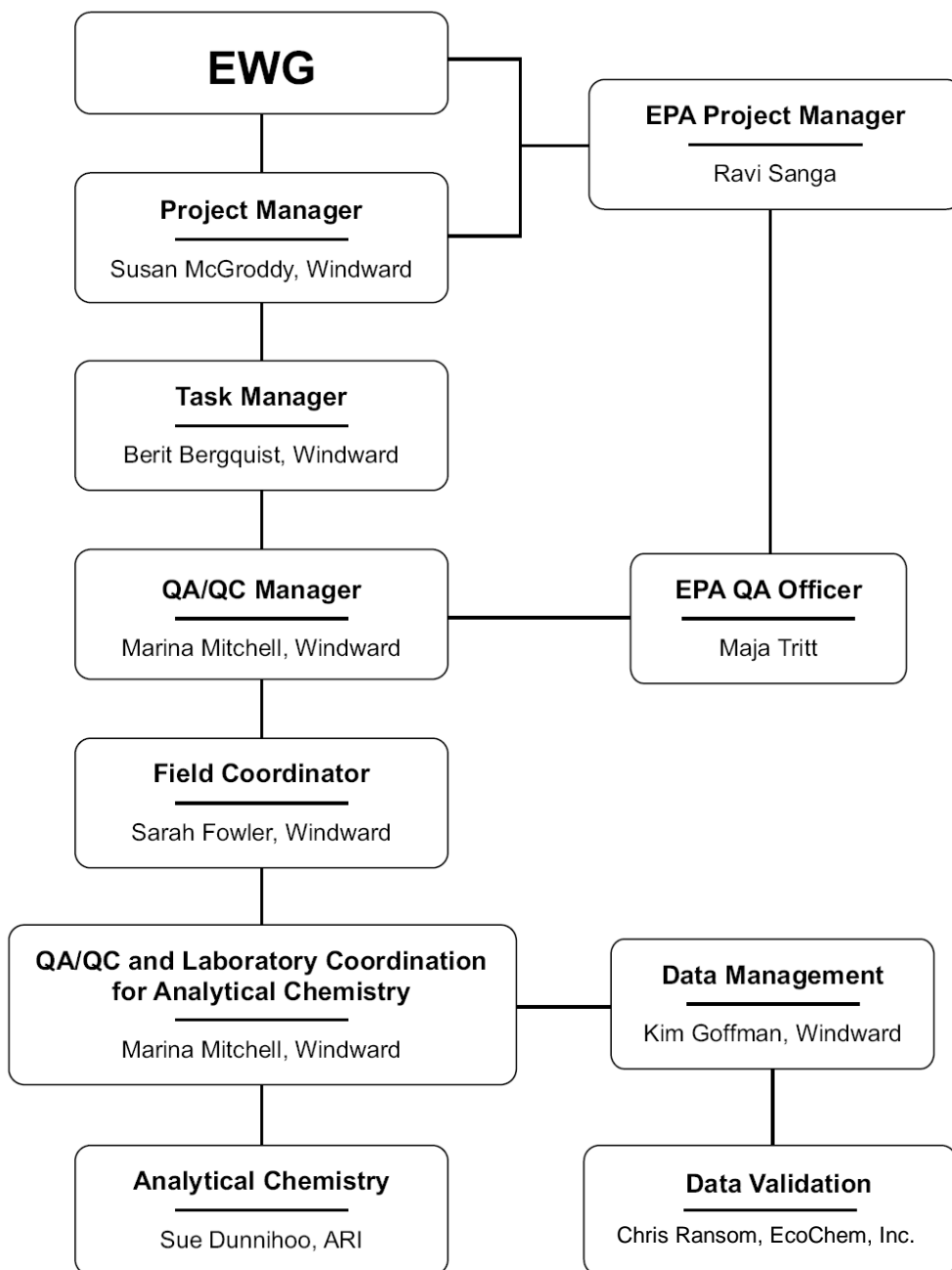


Figure 2-1. Project organization

2.1.1 Project management

EPA will be represented by its project manager (PM) for this project, Ravi Sanga. Mr. Sanga can be reached as follows:

Mr. Ravi Sanga
US Environmental Protection Agency, Region 10
1200 Sixth Avenue, Suite 900
ECL-111
Seattle, WA 98101-3140
Telephone: 206.553.4092
Facsimile: 206.553.0124
E-mail: Sanga.Ravi@epamail.epa.gov

Susan McGroddy will serve as the Windward PM and will be responsible for overall project coordination and providing oversight for planning and coordination, work plans, all project deliverables, and performance of the administrative tasks needed to ensure timely and successful completion of the project. She will also be responsible for coordinating with EWG and EPA on schedule, deliverables, and other administrative details. Dr. McGroddy can be reached as follows:

Dr. Susan McGroddy
Windward Environmental LLC
200 W Mercer Street, Suite 401
Seattle, WA 98119
Telephone: 206.812.5421
Facsimile: 206.217.0089
E-mail: susanm@windwardenv.com

Berit Bergquist will serve as the Windward task manager (TM). The TM is responsible for project planning and coordination, production of work plans, production of project deliverables, and performance of the administrative tasks needed to ensure timely and successful completion of the project. The TM is responsible for communicating with the Windward PM on the progress of project tasks and any deviations from the QAPP. Significant deviations from the QAPP will be further reported to EWG and EPA.

Ms. Bergquist can be reached as follows:

Ms. Berit Bergquist
Windward Environmental LLC
200 W Mercer Street, Suite 401
Seattle, WA 98119
Telephone: 206.812.5403
Facsimile: 206.217.0089
E-mail: beritb@windwardenv.com

2.1.2 Field coordination

Sarah Fowler will serve as Windward's field coordinator (FC). The FC is responsible for managing the field activities and for general field QA/QC oversight. She will ensure that appropriate protocols for sample collection, preservation, and holding times are observed and oversee the delivery of environmental samples to the designated laboratories for chemical analysis. Ms. Fowler can be reached as follows.

Ms. Sarah Fowler
Windward Environmental LLC
200 W Mercer Street, Suite 401
Seattle, WA 98119
Telephone: 206. 812.5440
Facsimile: 206.217.0089
E-mail: sarahf@windwardenv.com

2.1.3 Quality assurance/quality control

Marina Mitchell of Windward will serve as QA/QC manager for the project. As the QA/QC manager, she will provide oversight for the coordination of the field sampling and laboratory programs and will ensure compliance with the QAPP. She will also supervise data validation and project QA coordination, including coordination with the EPA QA officer, Maja Tritt. Ms. Mitchell can be reached as follows:

Ms. Marina Mitchell
Windward Environmental LLC
200 W Mercer Street, Suite 401
Seattle, WA 98119
Telephone: 206.812.5424
Facsimile: 206.217.0089
E-mail: marinam@windwardenv.com

Ms. Tritt can be reached as follows:

Ms. Maja Tritt
US Environmental Protection Agency, Region 10
1200 Sixth Avenue, Suite 900 (OEA-095)
Seattle, WA 98101
Telephone: 206.553.6265
E-mail: tritt.maja@epamail.epa.gov

Ecochem will provide independent third-party review and validation of analytical chemistry data. Chris Ransom will act as the data validation PM and can be reached as follows:

Mr. Chris Ransom
EcoChem, Inc.
Dexter Horton Building
710 Second Avenue, Suite 600
Seattle, WA 98104
Telephone: 206.233.9332, ext. 109
E-mail: cransom@ecochem.net

2.1.4 Laboratory project management

Ms. Mitchell of Windward will also serve as the laboratory coordinator for the analytical chemistry laboratory. Analytical Resources, Inc. (ARI), will perform chemical analyses on porewater samples. ARI will be responsible for analysis of all chemical analytes. The laboratory PM can be reached as follows:

Ms. Susan Dunnihoo
Analytical Resources, Inc.
4611 S 134th Place, Suite 100
Tukwila, WA 98168
Telephone: 206.695.6207
E-mail: sue@arilabs.com

ARI will do the following:

- ◆ Adhere to the methods outlined in this QAPP, including the methods referenced for each procedure
- ◆ Adhere to documentation, custody, and sample logging procedures
- ◆ Implement QA/QC procedures defined in this QAPP
- ◆ Meet all reporting requirements
- ◆ Deliver electronic data files as specified in this QAPP
- ◆ Meet turnaround times for deliverables as described in this QAPP
- ◆ Allow EPA and the QA/QC third-party auditors to perform laboratory and data audits

2.1.5 Data management

Kim Goffman will oversee data management to ensure that analytical data are incorporated into the EW database with appropriate qualifiers following acceptance of the data validation. QA/QC of the database entries will ensure accuracy for use in the ERA and human health risk assessment.

2.2 PROBLEM DEFINITION/BACKGROUND

EPA has identified the need to collect porewater samples for the analysis of VOCs, which are difficult to detect in bulk sediment because they are not readily adsorbed onto sediment, in order to assess risk to benthic invertebrates. To address this need, this QAPP provides the details for the sampling and analysis of VOCs in intertidal sediment porewater from EW. This section presents the objective, conceptual site model, and background information for this sampling effort and identifies areas for porewater sampling.

2.2.1 Objective

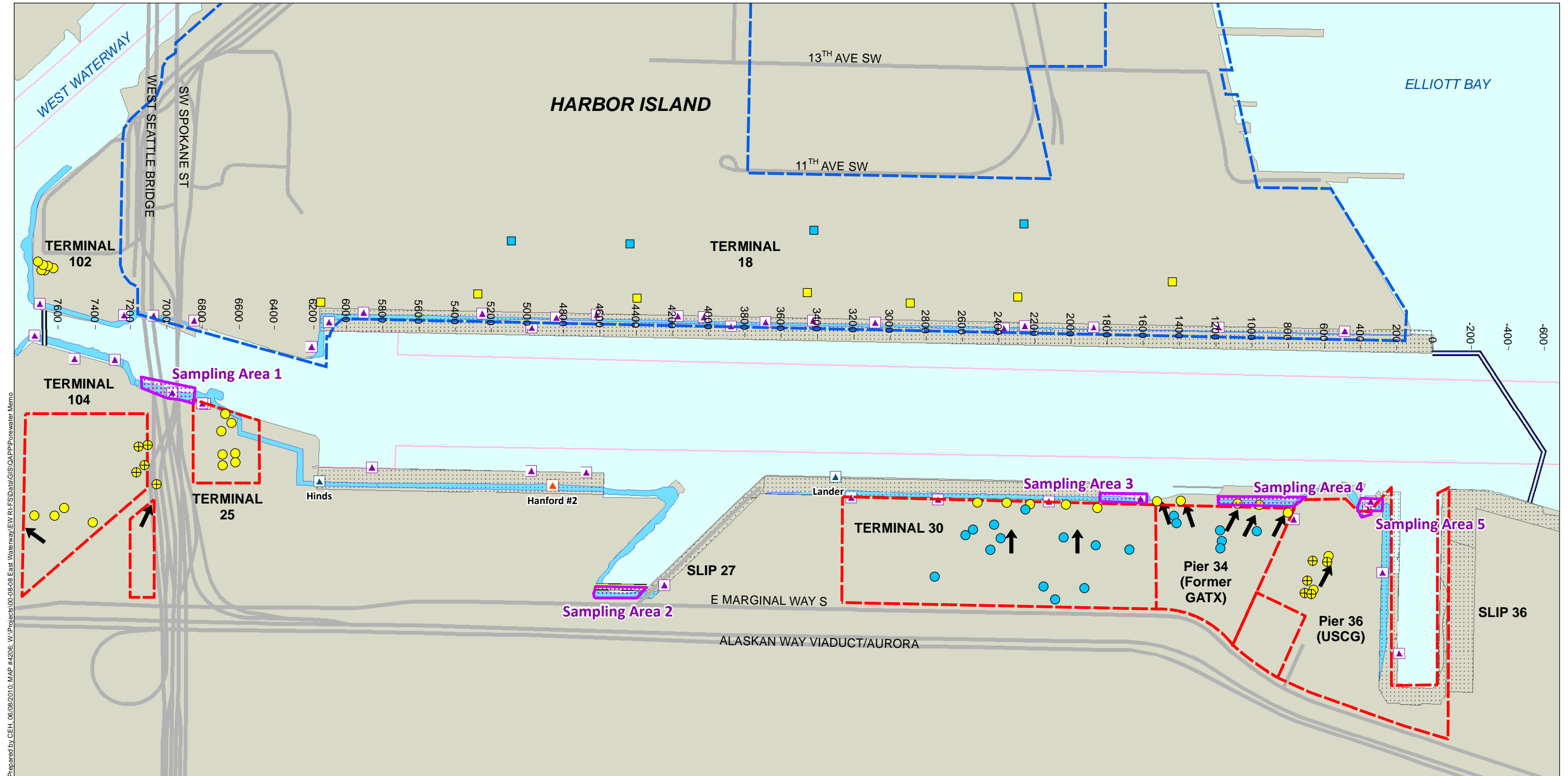
If there is a continuing source of VOC contamination to groundwater and that groundwater discharges to the EW, VOCs may be present in sediment porewater associated with those discharge areas (Church et al. 2002; Chadwick et al. 1999). VOCs do not have a high affinity for sediment because of their generally low organic carbon-normalized partition coefficient (K_{oc}) (Mabey et al. 1982). Therefore, the exposure of sediment-dwelling organisms (i.e., benthic invertebrates) to VOCs is most appropriately assessed through the analysis of sediment porewater rather than bulk sediment.

The purpose of the porewater study is to characterize VOC concentrations in sediment porewater at locations where VOCs have been detected in upland groundwater or where there are no upland groundwater data but intertidal sediment is suitable for sampling. Concentrations of VOCs in porewater from these locations will be compared with available water-based toxicological effects data for invertebrate species.

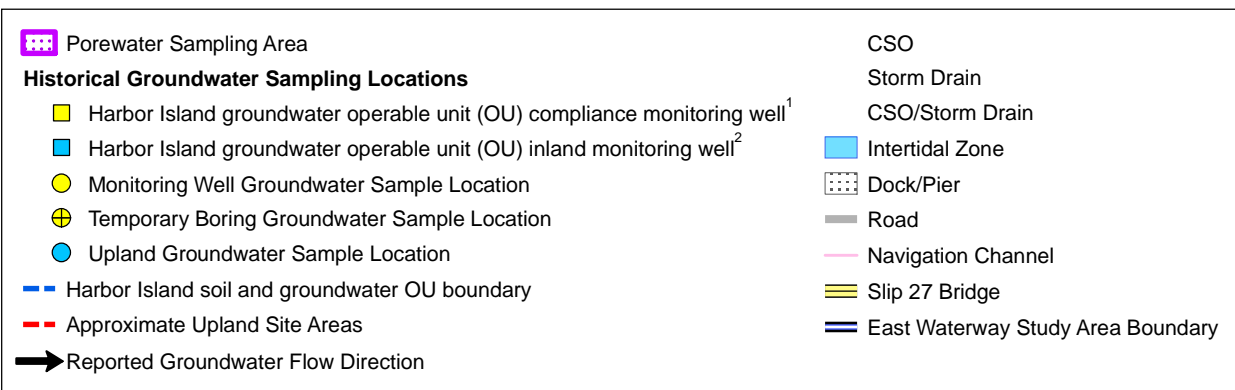
2.2.2 Conceptual site model

This section presents a general conceptual site model for the interaction of groundwater, surface water, and sediment porewater in the EW. Porewater, or interstitial water, is defined as the water that occupies the spaces between sediment particles.

The EW is a well-stratified estuary that is influenced by river flow and tidal effects. The typical tidal range in the EW is approximately 11 ft, based on the difference between a mean higher high water of 5.1 ft and a mean lower low water of 6 ft. Site-specific studies have shown that groundwater from upland areas adjacent to the EW generally flows toward the waterway (Map 2-1). However, tidal action can locally increase the variability of the groundwater flow patterns. High tides can temporarily cause an apparent groundwater flow reversal adjacent to the EW, with surface water temporarily flowing inland, although the net groundwater flow direction is towards the EW (Booth and Herman 1998a; Booth and Herman 1998b). Tidal changes in the EW have been reflected in groundwater levels in wells adjacent to the waterway (RETEC 2006). Because of these tidal fluctuations, porewater chemistry in EW sediment may be more influenced by either surface water or groundwater, depending on tidal conditions and the location and depth of collection.

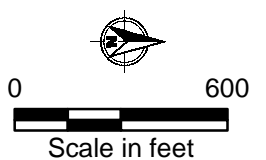


Prepared by CEH, 06/08/2010; MAP #4206; W:\Projects\00-08-08 East Waterway\EW\RFSD\GIS\QAPP\Porewater Memo



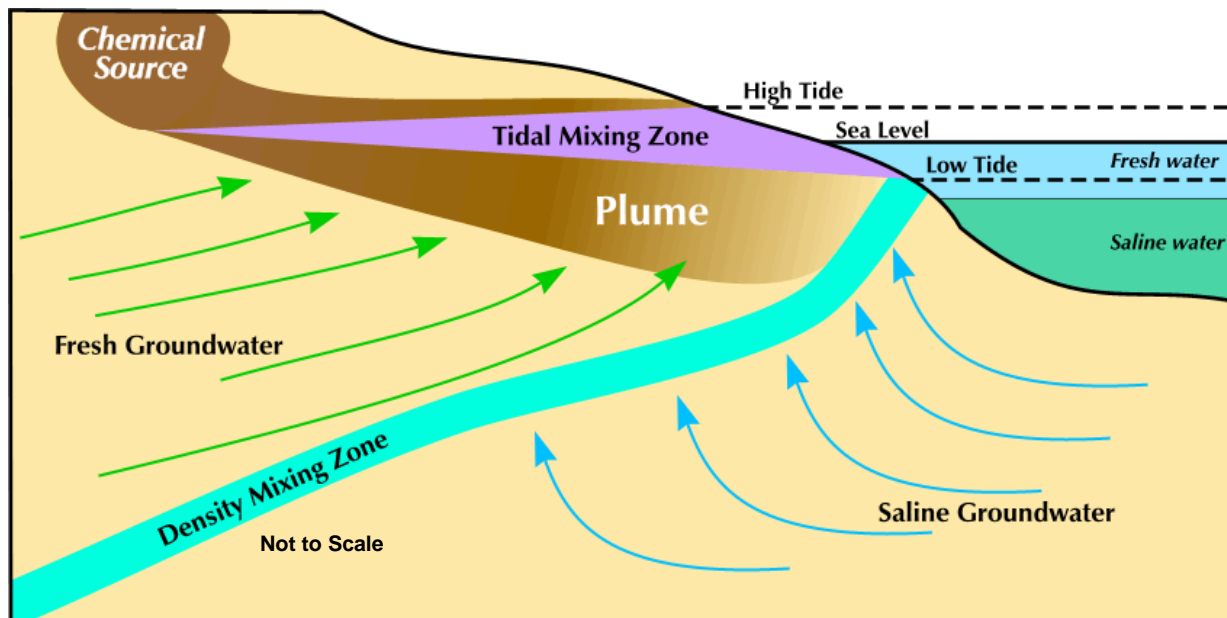
¹ "Compliance" is defined for the purposes of this report as wells closest to the East Waterway and does not reflect any well designations based on the Harbor Island Soil and Groundwater OU or related reports and agreements.

² "Inland" is defined for the purposes of this report as wells farther away from the East Waterway shoreline.



Map 2-1
Porewater Sample Locations
Porewater Sampling QAPP
East Waterway Study Area

In the EW, the freshwater layer, which moves downstream, overlies a tidally driven saltwater layer that extends upstream from Elliott Bay. These conditions result in the presence of saline water in the groundwater zone beneath the EW. Less dense, fresh groundwater will not readily mix with or migrate into the deep saltwater layer. As a result, the fresh groundwater migrating beneath the upland areas is likely to discharge into shallower intertidal areas of the EW when it encounters the denser saline groundwater layer located directly beneath the EW, as shown in Figure 2-2. Therefore, sediment porewater in nearshore intertidal areas is more likely to reflect upland groundwater chemistry than porewater in deeper areas of the EW. This focused discharge of fresh groundwater in the intertidal zone is illustrated in Figure 2-2. The groundwater monitoring data from Terminal 30 (T-30) confirmed this conceptual site model. Groundwater monitoring and hydrodynamic modeling at T-30 confirmed that the lower-density upland groundwater flows vertically upward, with most of the discharge focused in the intertidal zone (RETEC 2006).



Source: Figure adapted from Slide 3 of NFEC (2003).¹

Figure 2-2. Conceptual site model of groundwater-surface water interaction

2.2.3 Historical data

Numerous groundwater investigations have been conducted along upland areas adjacent to the EW and the groundwater monitoring well locations for these investigations are shown on Map 2-1. These investigations have been performed

¹ The original figure represented marine conditions, although in principle, the same features should apply to a salt-wedge estuary. The configuration of the density mixing zone (i.e., the zone where saline and freshwater mix) is site-specific, and may be broader than that shown.

voluntarily as part of area planning and/or development activities in coordination with EPA and Washington State Department of Ecology (Ecology) programs. Upland cleanup sites are discussed in detail in the East Waterway Operable Unit SRI/FS Final Initial Source Evaluation and Data Gaps Memorandum (Anchor and Windward 2009). A general discussion of these sites and groundwater conditions along the west and east shorelines of the EW is presented below; Table 2-1 presents a summary of selected groundwater monitoring events and detected concentrations of VOCs. Table 2-1 also compares detected VOC concentrations with available water toxicity benchmarks (no-observed-effect concentrations [NOECs]) that were developed as part of the porewater data report for the Lower Duwamish Waterway (Windward 2006).

Table 2-1. Groundwater monitoring events conducted adjacent to the East Waterway and summary of VOC results

Event	Reference	Number of Nearshore and/or Downgradient Wells ^a	Number of Groundwater Samples	VOCs Detected	Detection Frequency ^b	VOC Concentration (µg/L)		
						Minimum	Maximum	NOEC ^c
T-25 1989 to 1990 groundwater sampling	Sweet-Edwards/EMCON (1990)	4	4	none ^d	na	na	na	na
T-102 underground storage tank decommissioning	RETEC (1997)	6	6	none ^d	na	na	na	na
USCG (Pier 36) 2003 and 2004 groundwater monitoring	Hart Crowser (2004)	7	7	1,1,2-trichloroethane	1/7	6.6	6.6	1,000
				xylenes	2/7	1.1	5.3	1,168
				other VOCs ^e	2/7	1.1	18.0	nd
GATX (Pier 34) 2003 groundwater monitoring	RETEC (2004)	6 ^f	12	benzene ^d	1/6	18	29	180
				ethylbenzene ^d	1/6	3.4	3.4	nd
				xylenes ^d	1/6	1.5	3.5	1,168
				toluene ^d	1/6	1.2	1.2	737
Harbor Island 2005 to 2006 groundwater monitoring	RETEC (2006)	7	14 ^g	benzene ^h	1/7	1	1.4	180
T-104 vicinity 2005 to 2007 groundwater sampling	Environmental Partners (2007)	9	15	cis-1,2-dichloroethene ⁱ	1/14	0.4	0.4	6,785
				trichloroethene ⁱ	3/14	0.89	4	1,700
				toluene ⁱ	4/13	0.27	0.75	737
				m,p-xylenes ⁱ	1/13	0.52	0.52	1,168
T-30 second quarter 2009 groundwater sampling event	AECOM (2009)	5	5	none ^d	na	na	na	na

^a Located in areas where groundwater is known to flow towards the EW.

^b Detection frequency represents number of wells sampled in which chemical was detected.

^c NOEC concentrations were developed for the LDW for the evaluation of risk to benthic invertebrates from porewater exposure (Windward 2006).

^d Samples were analyzed for BTEX chemicals only

^e Other VOCs that were analyzed for and detected included isopropylbenzene, n-propylbenzene, 4-chlorotoluene, 1,3,5-trimethylbenzene, tert-butylbenzene, 1,2,4-trimethylbenzene, sec-butylbenzene, isopropyltoluene, n-butylbenzene, and naphthalene.

^f Groundwater monitoring at GATX included one seep sample. Monitoring for each well and seep sample for the groundwater sampling was conducted during April and August 2003.

^g Quarterly monitoring of each well for groundwater sampling conducted September and December 2005 and March and June 2006.

^h Samples were analyzed for trichloroethane, benzene, carbon tetrachloride and tetrachloroethene

ⁱ Samples were analyzed for the full suite of priority VOCs

BTEX – benzene, toluene, ethylbenzene, and xylene

nd – no data (no toxicity data were available in the LDW porewater evaluation (Windward 2006))

T-104 – Terminal 104

USCG – US Coast Guard

VOC – volatile organic compound

EW – East Waterway

NOEC – no observed effect concentration

GATX – GATX Terminals Corporation

T-25 – Terminal 25

LDW – Lower Duwamish Waterway

T-30 – Terminal 30

na – not applicable

On the western side of the EW, groundwater monitoring has been conducted at two sites: Terminal 102; and the Harbor Island Soil and Groundwater Operable Unit (OU) No. 1, a component of the larger Harbor Island Superfund site (Map 2-1). A Record of Decision was issued for OU No. 1 in 1993 and followed by completion of several investigations and cleanup actions. The majority of the remedial actions were completed in 2004 (Anchor and Windward 2009). Benzene was the only VOC detected in nearshore groundwater monitoring wells on the western side of the EW and was only detected in one well at a maximum concentration of 1 µg/L, which is substantially lower than the NOEC of 180 µg/L.

Cleanup sites along the eastern shoreline of the EW include a variety of historical and existing industrial sites. These sites include areas of Pier 36 (US Coast Guard facility), Pier 34 (former GATX Terminals Corporation [GATX]), T-30, Terminal -25 (T-25), and Terminal 104 (T-104). At the Pier 36 and Pier 34 sites, several VOCs were infrequently detected in nearshore or downgradient groundwater monitoring wells at concentrations well below the available NOECs (Table 2-1). No VOCs were detected in groundwater monitoring wells along the shoreline of T-30 (Table 2-1).

2.3 PROJECT/TASK DESCRIPTION AND SCHEDULE

This section provides an overview of the sampling and analysis activities for the studies designed to address the data needs outlined in Section 2.2. Samples from the EW will be collected using piezometers and will be analyzed for VOCs to assess the potential for adverse effects on benthic invertebrates.

Piezometers will be installed following the approval of the QAPP. Immediately following the installation of piezometers, porewater samples will be collected, and the piezometers will be removed. The samples will be analyzed at ARI for VOCs as specified in Section 3.4.1, with a standard turnaround time of 3 weeks. Chemical data will be validated within 3 weeks of receiving data packages from ARI. A draft data and analysis report with the results of the validated chemical analyses will be submitted to EPA within 8 weeks of receiving data packages from ARI. This report is termed a data and analysis report because in addition to presenting data from the field event, this report will also compare the results to relevant toxicity data or toxicity-based criteria, if available, to allow a more expedient determination of whether any additional porewater sampling in the EW is warranted.

2.4 QUALITY OBJECTIVE AND CRITERIA FOR CHEMICAL DATA

The overall data quality objective (DQO) for this project is to develop and implement procedures that will ensure the collection of representative data of known, acceptable, and defensible quality. Parameters used to assess data quality are precision, accuracy, representativeness, comparability, completeness, and sensitivity. These parameters are discussed in detail in Section 3.4.2, along with specific data quality indicators (DQIs) for porewater laboratory analyses.

2.5 SPECIAL TRAINING/CERTIFICATION

The Superfund Amendments and Reauthorization Act of 1986 required the Secretary of Labor to issue regulations providing health and safety standards and guidelines for workers engaged in hazardous waste operations through the Occupational Safety and Health Administration (OSHA). Regulation 29 CFR 1910.120 requires training to provide employees with the knowledge and skills necessary to enable them to perform their jobs safely and with minimum risk to their personal health. All sampling personnel will have completed the 40-hour hazardous waste operations and emergency response (HAZWOPER) training course and 8-hour refresher course, as necessary, to meet the requirements of the OSHA regulations.

2.6 DOCUMENTATION AND RECORDS

This section describes documentation and records to be kept during field activities and laboratory analyses. It also describes the data reduction process and the contents of the data and analysis report.

2.6.1 Field observations

All field activities will be recorded in a field notebook maintained by the FC. The field notebook will provide a description of all field activities, conferences associated with field activities, field personnel, weather conditions, and a record of all modifications to the procedures and plans identified in this QAPP and the HSP (Appendix A). The field notebook will consist of bound, numbered pages. All entries will be made in indelible ink. The field notebook will provide sufficient data and observations to enable participants to reconstruct events that occurred during the sampling period.

The following information will be recorded on the Porewater Piezometer Collection Form (Form 1, Appendix B):

- ◆ Project name and task designation
- ◆ Date and time of sample collection and name of person filling out form
- ◆ Names of crew members
- ◆ Weather conditions
- ◆ Sample identification (ID)
- ◆ Sampling method
- ◆ Location (i.e., global positioning system [GPS] coordinates)
- ◆ General description of surface substrate, including indication of the possible presence of anthropogenic fill or waste material
- ◆ Description of porewater sampling locations
- ◆ Results for porewater conventional parameters

Any deviations from the field procedures specified in this QAPP will be documented on the Protocol Modification Form (Form 2, Appendix B).

2.6.2 Laboratory records

The laboratory will be responsible for performing internal checks on sample handling and analytical data reporting and will correct errors identified during QA review. Any corrective actions that are required by the laboratory will be documented in the case narrative. Close communication will be maintained between the laboratory and the QA/QC manager to resolve any QC problems in a timely manner. The laboratory data package will include the following:

- ◆ **Project narrative** – This summary, in the form of a cover letter, will present any problems encountered during any aspect of analysis. The summary will include, but not be limited to, discussions of QC, sample delivery, sample storage, and analytical difficulties. Any problems encountered, whether actual or perceived, and their resolutions will be documented in as much detail as necessary. In addition, instrument operating conditions used for the VOC analysis and definitions of laboratory qualifiers will be provided.
- ◆ **Records** – Legible copies of the chain-of-custody (COC) forms will be provided as part of the data package. This form will include the time of receipt and the condition of each sample received by the laboratory. Additional internal tracking of sample custody by the laboratory also will be documented.
- ◆ **Sampling results** – Data packages will be submitted for both full and summary data validation. The data validation packages will include all raw data. **QA/QC summaries** – These summaries will contain the results of all QA/QC procedures. Each QA/QC sample analysis will be documented with the same information required for the sample results (see above). The laboratory will make no recovery or blank corrections. The required summaries are listed below; additional information may be requested.
 - ◆ Calibration data summary will contain the concentrations of the initial calibration and daily calibration standards and the date and time of analysis. The response factor, percent relative standard deviation (%RSD), percent difference, and retention time for each analyte will be listed, as appropriate. Results for low-level standards run to establish instrument sensitivity will be reported.
 - ◆ Performance summary report for each instrument will contain a list of the samples for which the performance checks are applicable.
 - ◆ Internal standard area summary will report the internal standard areas, as appropriate.

- ◆ Method blank analysis summary will report the method blank analysis associated with each sample and the concentrations of all compounds of interest identified in these blanks.
- ◆ Surrogate spike recovery summary will report all surrogate spike recovery data for VOC analyses. The names and concentrations of all compounds added, percent recoveries, and QC limits will be listed.
- ◆ Matrix spike recovery summary will report the matrix spike or matrix spike/matrix spike duplicate (MS/MSD) recovery data for analyses, as appropriate. The names and concentrations of all compounds added, percent recoveries, and QC limits will be included in the data package. The relative percent differences (RPDs) for all MS/MSD analyses will be reported.
- ◆ Matrix duplicate summary will report the RPDs for all matrix duplicate analyses. The QC limits for each compound or analyte will be listed.
- ◆ Laboratory control analysis summary will report the results of the analyses of laboratory control samples (LCS). The QC limits for each compound or analyte will be included in the data package.
- ◆ **Original data** – Electronic copies of the original data generated by the laboratory will be provided and include the following:
 - ◆ Sample refrigerator temperature logs
 - ◆ Sample extraction and preparation logs
 - ◆ Instrument specifications and analysis logs for all instruments used on days of calibration and analysis
 - ◆ Reconstructed ion chromatograms for all samples, standards, blanks, calibrations, spikes, replicates, and LCS
 - ◆ Raw and enhanced spectra of detected compounds with associated best-match spectra for each sample
 - ◆ Printouts and quantitation reports for each instrument used, including reports for all samples, standards, blanks, calibrations, spikes, and replicates
 - ◆ Original data quantitation reports for each sample

The contract laboratory for this project, ARI, will submit data electronically, in delimited-text format. Guidelines for electronic data deliverables (EDDs) for chemical data are as follows:

- ◆ Each row of data will contain only one analyte for a given sample. Therefore, one complete sample will require multiple rows.
- ◆ If a comma-separated value file format has been used, all fields must have quotations around each entry to avoid field value confusion (e.g., “1,1,2-trichloroethane”).

- ◆ Each result, reporting limit, and detection limit must show the proper significant figures and sensitivity.
- ◆ If a result for an analyte is below the detection limit, the laboratory qualifier will be U (not detected at given concentration), and the value in the result column will be the reporting limit.
- ◆ Analytical results of laboratory samples for QA/QC will be included and clearly identified in the sample type code field.
- ◆ If replicate analyses are conducted on a submitted field sample, they too will be included and clearly identified in the sample type code.
- ◆ Wherever possible, all analytes and replicates for a given sample will be grouped together.
- ◆ If an analyte is not detected, then the laboratory qualifier will be U, and the value in the result column will be the sample-specific reporting limit. Quantified results between the detection limit and the reporting limit will be laboratory J-qualified (estimated concentration).

The EDD format for chemical data is provided in Table 2-2.

Table 2-2. Electronic data deliverable format for chemical data

Field	Required or Optional
Project code	required
Event ID	required
Sample name	required
Sample date time	required
Analysis location	required
Laboratory name code	required
Parent sample name	optional
Laboratory sample ID	required
Sample type code	required
Sample delivery group	required
Standard analytical method name	required
Laboratory analytical method name	optional
CAS number	optional
Chemical name	required
Result value	required
Result unit	required
Lab flag	optional
Validator flag	optional
Result type code	required
Detect flag	required
Reporting detection limit	required

Field	Required or Optional
Dilution factor	required
Sample matrix code	required
Total or dissolved	required
Basis	required
Analysis date time	required
Method detection limit	required
Laboratory prep method name	required
Prep date time	required
Test batch ID	required
Result error delta	optional
TIC retention time	optional
Result comment	optional
QC original concentration	optional
QC spike added	optional
QC spike measured	optional
QC spike recovery	optional
QC duplicate original concentration	optional
QC duplicate spike added	optional
QC duplicate spike measured	optional
QC duplicate spike recovery	optional
QC RPD	optional
QC spike LCL	optional
QC spike UCL	optional
QC RPD CL	optional
Lab analytical method description	optional
Lab flag description	optional

CAS – Chemical Abstracts Service

ID – identification

LCL – lower control limit

QC – quality control

RPD – relative percent difference

TIC – tentatively identified compound

UCL – upper control limit

2.6.3 Data reduction

Data reduction is the process by which original data (analytical measurements) are converted or reduced to a specified format or unit to facilitate analysis of the data. Data reduction requires that all aspects of sample preparation that could affect the test result, such as sample volume analyzed or dilutions required, be taken into account in the final result. It is the laboratory analyst's responsibility to reduce the data, which are subjected to further review by the laboratory PM, the Windward PM, the project QA/QC coordinator, and independent reviewers. The data will be generated in a form

amenable to review and evaluation. Data reduction may be performed manually or electronically. If performed electronically, all software used must be demonstrated to be true and free from unacceptable error.

2.6.4 Data and analysis report

A data and analysis report, as described in Section 2.3, will be prepared by Windward to document all activities associated with the collection, handling, and analysis of samples. At a minimum, the following will be included in the data and analysis report:

- ◆ Summary of all field activities, including deviations from the approved QAPP
- ◆ Porewater sampling locations reported in northing, easting, and elevation to the nearest tenth of a foot
- ◆ Plan view of the project that shows actual sampling locations
- ◆ Piezometer purge logs, including basic conventional water quality parameter results and volume purged prior to porewater sample collection
- ◆ Summary of the QA/QC review of the chemical data
- ◆ Copies of field logs (appendix)
- ◆ Data validation report (appendix)
- ◆ Tables of all raw data (appendix)
- ◆ Results from the analyses of porewater samples, both as summary tables in the main body of the report and appendices with data forms submitted by the laboratories and as cross-tab tables produced from Windward's database
- ◆ Comparison of porewater VOC concentrations with relevant toxicological effects data for invertebrates

Chemical data packages will be received from the laboratories no later than 3 weeks after the last sample was submitted. Chemical data will be validated within 3 weeks of the receipt of data packages from the laboratory. The draft data and analysis report, including electronic versions of the data, will be submitted to EPA. A draft final version of the data and analysis report will be submitted for approval approximately 4 weeks after the receipt of comments on the draft version.

3 Data Generation and Acquisition

This section describes the methods that will be used to collect porewater samples for VOC analysis at selected intertidal locations in the EW. Elements include sampling design, porewater sampling methods, sample handling and custody requirements, decontamination procedures, analytical methods, QA/QC, instrument/equipment testing, inspection and maintenance, instrument calibration, supply inspection/acceptance, and data management.

3.1 STUDY DESIGN

This section presents the rationale and design for the selection of four sampling areas in the EW (Map 2-1) and for the placement of piezometers within the four sampling areas for the collection of porewater from sediment.

No VOC groundwater plumes are known to be present in the vicinity of the EW based on historical data presented in Section 2.2.3. On the east side of the EW, porewater samples will be collected in the vicinity of each of the five sites for which there is historical groundwater data, as well as in Slip 27, where groundwater has not been previously characterized. . These four porewater sampling areas are as follows: Area 1 is located under the Spokane Street bridge near T-104 and T-25; Area 2 is located at the head of Slip 27; Area 3 is near T-30 and Pier 34, and Area 4 is near Pier 36. Porewater samples will not be collected on the west side of the EW because data indicate that VOCs are not present in groundwater at concentrations of concern (Table 2-1).

Within each area, the field crew will identify three sampling locations that are suitable for piezometer sampling; these locations will be distributed horizontally across the intertidal sampling area. A summary of the sample IDs and the rationale for each sampling area are provided in Table 3-1. Each piezometer will be deployed so that the top of the screen is approximately 15 to 30 cm below the mudline but may need to be placed shallower or deeper to obtain a suitable porewater sample. The exact depth will be determined based on conditions encountered during piezometer installation. Porewater samples will be collected during the 4 hours that encompass the latter half of the falling tide using low-flow purging as described in Section 3.2.3. Samples will be submitted to the laboratory for the analysis of VOCs using EPA 8260B.

Table 3-1. Porewater sampling areas and rationale

Sampling Area	Rationale for sampling area
Area 1	spatial coverage and historical low-level detections of VOCs at T-25
Area 2	spatial coverage in an area with no groundwater data
Area 3	spatial coverage; consistent low-level detected concentrations of VOCs in upland groundwater at T-30 (former Chevron facility) and Pier 34 (former GATX facility)
Area 4	Spatial coverage; historical low-level detections of VOCs at Pier 36 (USCG facility) and former Rabanco dock

GATX – GATX Terminals Corporation

ID – identification

T-25 – Terminal 25

VOC – volatile organic compound

NAD83 – North American Datum of 1983

USCG – US Coast Guard

3.2 SAMPLING METHODS

The methods for sampling porewater are described in this section. All field activities will be performed under the direction of the Windward FC.

3.2.1 Sample identification

Each porewater sample will be assigned a unique alphanumeric sample ID number. The first two characters of the sample ID are “EW” to identify the East Waterway project area. The next two characters are “PW” to identify the medium sampled (i.e., porewater), followed by “PZ” to signify the type of sample (i.e., piezometer). The next two characters identify the sampling area (e.g., “A1” for Area 1). The last two characters are consecutive numbers, beginning with 01, to identify the sample number. For example, the sample ID of the first porewater sample collected from Area 1 is EW-PW-PZ-A1-01. Field QA/QC samples will be assigned modified sample IDs as described below:

- ◆ Field replicates will be identified using sample numbers starting with 201. For example, the first field replicate sample collected will be identified as EW-PW-PZ- 201.
- ◆ Identifiers for VOC trip and equipment blanks will contain the prefix “EW-PW,” followed by a unique numeric identifier and the letters “TB” or “EB” to designate trip blank or equipment blank, respectively. For example, the first trip blank submitted to the laboratory would be EW-PW-01-TB.

3.2.2 Location positioning

Sample locations will be selected in order to collect porewater samples from intertidal sediments that are hosting or conveying the lowest salinity porewaters. In order to screen for these lowest salinity porewaters a comprehensive approach is described below to screen for locations with the freshest water. Overall, this approach will consist of inserting a piezometer into the sediments along a transect at approximately regular intervals. The sampler is inserted by hand into the sediments to a depth of approximately one-foot. The lower portion of the pipe is slotted to allow the entry of groundwater in the area of the tip. This ground water is extracted by suction provided by a peristaltic pump the discharge of which is evaluated for conductivity either optically or using an electrical conductivity meter. Sampling will be done by sequentially probing along a transect parallel to the tide line at a minus tide. The transect will be located at the zero foot MLLW line or lower. In the event the piezometer setup described above is found to be unsuitable for sampling due to the presence of large rocks, debris, or cobbles, alternate locations should be tried.

Previous studies in EWW such as the extensive groundwater monitoring and modeling that was conducted at T-30, have shown that the greatest discharge of groundwater occurs on low slack tide when the tide is at 0 MLLW or lower and during the rising phase of the tidal cycle while it is still below 0 MLLW.

If the sampler cannot be inserted to the desired depth at a location, an alternate sampling strategy using a driven 3-foot length of iron water pipe may be used to insert a mini – well of polyethylene tubing and equipped with a mini-well screen supplied by the EPA for this project. This method requires more time than the piezometer

screening and the sampling intervals will be larger than 10ft for this method. EPA field oversight will be provided to make field decisions regarding the sampling protocol.

Sampling Area 1 will be screened with piezometer probes on approximately 10 foot centers along the length of the intertidal area (approximately 300-foot length). The area south of the bridges consists of coarse gravel. It is likely that this area will require the iron water pipe and therefore, the screening interval will be adjusted in consultation with EPA. The lowest 3 (with a maximum 4) conductivity locations will be immediately re-sampled for VOC analysis as described below.

Sampling Area 2 will be screened along the length of the intertidal area (approximately 300-foot length). The sediments in this area are coarse and the iron water pipe may be required across the beach. The lowest 3 (with a maximum 4) conductivity locations will be immediately re-sampled for VOC analysis.

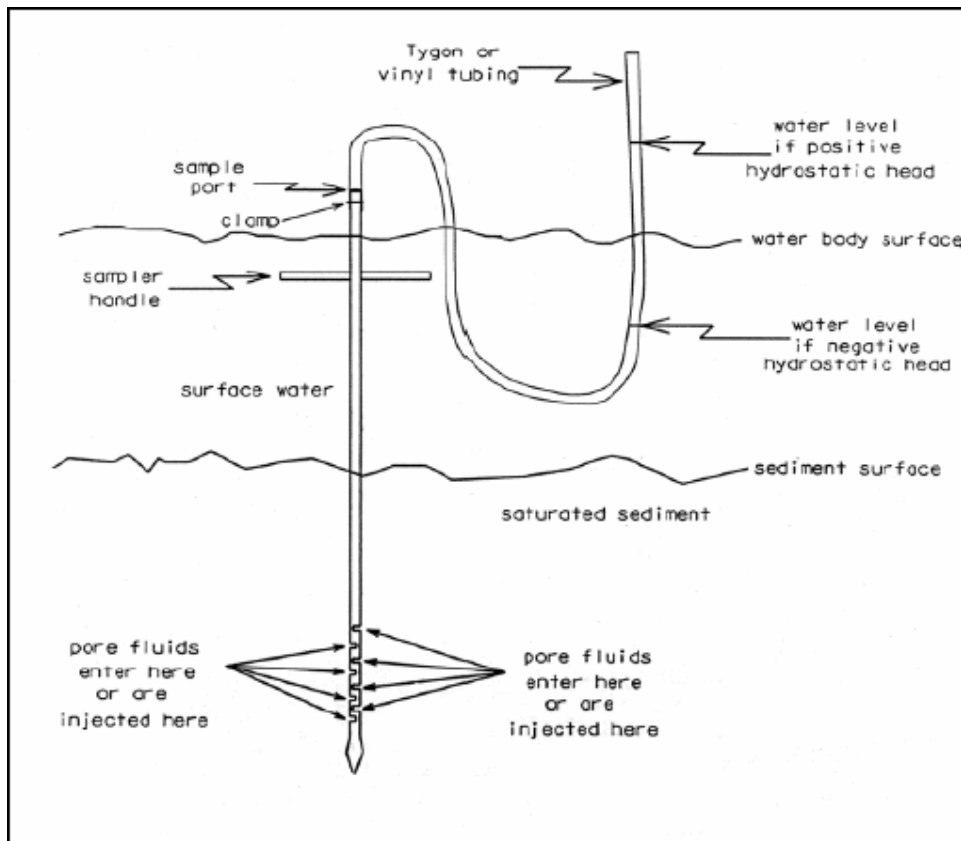
Sampling Area 3 will be screened along the length of the intertidal area (approximately 275 foot length) between the T30 and old Pier 34 sheet pile structures. The sediment in this area appears to be very coarse and the iron water pipe may be required in this area and therefore, the screening interval will be adjusted in consultation with EPA. Three samples should be collected - the first from the lowest observed location seen during screening and the others seeking spatial diversity of the samples from remaining low-electrical conductivity sites, immediately following the screening effort.

Sampling Area 4 will be screened along the length of the intertidal area (approximately 100 foot length). The sediment in this area appears to be very coarse and the iron water pipe may be required in this area and therefore, the screening interval will be adjusted in consultation with EPA. The lowest 2 conductivity locations will be sampled for analysis. These samples should be selected from 2 different areas with the lowest conductivity measured.

Sampling locations will be recorded by GPS. The GPS unit will receive signals from satellites to produce positioning accuracy to within 0.1 ft. Washington State Plane Coordinate System North coordinates in North American Datum of 1983 (NAD83) will be used for the horizontal datum and North American Vertical Datum of 1988 (NAVD88) will be used for the vertical datum. Obtaining GPS coordinates in Area 1 has proven to be difficult because of interferences from the bridge structures. A laser range finder will be used in this area to triangulate locations from known positions.

3.2.3 Porewater sample collection

Piezometers (i.e. Henry Samplers, etc.) are made of small-diameter 316 stainless steel and have a screened zone that consists of a series of interlaced machined slots (Figure 3-1). They will be installed so the top of the screen is about 15 to 30 cm below the mudline. Once the desired depth is reached, the internal guard rod will be removed from the probe body. A peristaltic pump and flexible tubing compatible with the pump will be attached to the top of the piezometer.



Source: MHE (2001)

Figure 3-1. Piezometer sampling set up

The peristaltic pump and tubing will be used with a multi-parameter probe and flow-through cell to purge the piezometer using low-flow methods (Puls and Barcelona 1996). Low-flow purging refers to the velocity at which water enters the pump tubing and is removed from the sediment porewater in the immediate vicinity of the well screen. The objective is to purge the piezometer in a manner that minimizes stress (water level drawdown), to the system to the extent practicable, taking into account established site sampling objectives. Typically, flow rates are on the order of 0.1 to 0.5 L per minute; however, this is dependent on site-specific conditions. The stabilization of parameters such as pH, specific conductance, dissolved oxygen (DO), oxidation-reduction potential, temperature, and turbidity will be monitored to determine when porewater is accessed during purging. Performance criteria for determining stabilization will be based on water-level drawdown, pumping rate, and the stabilization of indicator parameters.

A multi-parameter probe capable of measuring pH, electrical conductivity, oxidation-reduction potential, turbidity and DO, with a flow-through cell will be placed in line after the peristaltic pump. This will allow the parameters to be measured at short intervals and prior to the purged waters' exposure to air. During purging, the water level within the piezometer will be measured and the purge rate will be adjusted, as

needed, to minimize drawdown to less than 0.33 ft. Measurements will be recorded every 3 to 5 minutes, and stabilization will be reached when three successive readings are within ± 0.1 for pH, $\pm 3\%$ for electrical conductivity, ± 0 mV for oxidation-reduction potential, and $\pm 10\%$ for turbidity and DO. Following stabilization, porewater samples will be collected directly from the discharge tubing into three 40-mL vials with septa caps (pre-preserved with hydrochloric acid). Care will be taken to avoid the entrapment of air bubbles in the sample. The sample vial will be filled from the bottom to the top, leaving no headspace, and will be checked to ensure that no air bubbles are trapped in the vial.

3.2.4 Field equipment

The items needed in the field for porewater sampling are identified in Table 3-2. Windward will obtain the piezometers. The FC will check that all equipment is included and in working order each day before sampling personnel go into the field.

Table 3-2. Porewater sampling field equipment

Field Equipment	
QAPP	Stakes
Health and safety plan	40-mL vials with septa cap and hydrochloric acid
Field sample collection forms	Trip blanks
Field notebooks (Rite in the Rain [®])	Multi-parameter probe with flow-through cell
COC forms	Squirt bottle with distilled water
Pens, pencils, Sharpies [®]	Extra membranes for Hydrolab [®] DO probe
GPS (with extra batteries)	Gloves
Digital camera	Rubber boots
Cellular phone	Rain gear
Garbage bags	Re-sealable sandwich bags
Coolers	Waders
Ice (wet)	Syringes
EW maps including property boundaries	Flexible tubing
Porewater location coordinates	Shovel
Peristaltic pump	Water level meter
Slide hammer	Alconox [®]
Piezometers	Flagging tape

COC – chain of custody

DO – dissolved oxygen

EW – East Waterway

GPS – global positioning system

QAPP – quality assurance project plan

3.2.5 Decontamination procedures

The piezometers will be decontaminated prior to use following Puget Sound Estuary Program (PSEP) (1997) guidelines, as follows:

1. Rinse with EW water until free of sediment.
2. Wash with phosphate-free detergent.
3. Rinse with distilled water.

During the collection of porewater, the decontamination of tubing is not necessary because pre-cleaned equipment will be used at each location. Acid or solvent washes will not be used in the field because of safety considerations and problems associated with rinsate disposal and sample integrity, specifically:

- ◆ Use of acids or organic solvents may pose a safety hazard to the field crew.
- ◆ Disposal and spillage of acids and solvents during field activities pose an environmental concern.
- ◆ Residues of solvents and acids on sampling equipment may affect sample integrity for chemical testing.

Any sampling equipment that cannot be cleaned to the satisfaction of the FC will not be used for further sampling.

3.2.6 Field-generated waste disposal

All disposable sampling materials and personal protective equipment used in sample processing, such as gloves and paper towels, will be placed in heavyweight garbage bags or other appropriate containers. Disposable supplies will be removed from the site by sampling personnel and placed in a normal refuse container for disposal as solid waste.

3.3 SAMPLE HANDLING AND CUSTODY

This section describes how individual samples will be processed, labeled, tracked, stored, and transported to the laboratory for analysis. In addition, this section describes sample custody procedures and shipping requirements. Sample custody is a critical aspect of environmental investigation. Sample possession and handling must be traceable from the time of sample collection, through laboratory and data analysis, to the delivery of sample results to the recipient.

3.3.1 Sample handling procedures

After porewater samples have been placed in three 40-mL glass vials with septa caps, each vial will be sealed and labeled. Each sample label will contain the project number, sample ID, preservation technique, analyses, date and time of collection, and initials of the person(s) preparing the sample. Sample labels will be filled out as completely as possible prior to the field event. Once completed, the sample label will be affixed to

each sample container and covered with clear tape. The vials will be placed in a re-sealable plastic bag by location and placed in a cooler with wet ice. One trip blank will be included in each cooler.

3.3.2 Sample custody procedures

Samples are considered to be in custody if they are: 1) in the custodian's (e.g., field or laboratory personnel's) possession or view, 2) retained in a secured place (under lock) with restricted access, or 3) placed in a container and secured with an official seal(s) such that the sample cannot be reached without breaking the seal(s). Custody procedures will be used for all samples throughout the collection, transport, and analytical process, and for all data and data documentation whether in hard copy or electronic format. Custody procedures will be initiated during sample collection. A COC form will accompany samples to the analytical laboratory. Each person who has custody of the samples will sign the COC form and ensure that the samples are not left unattended unless properly secured. Minimum documentation of sample handling and custody will include:

- ◆ Sample location, project name/task, and unique sample ID number
- ◆ Sample collection date and time
- ◆ Any special notations on sample characteristics or problems
- ◆ Initials of the person who collected the sample
- ◆ Date sample was delivered to the laboratory

The FC will be responsible for all sample tracking and custody procedures in the field and for final sample inventory, as well as for maintaining sample custody documentation. The FC will also complete COC forms prior to removing samples from the sampling area. At the end of each day, and prior to transfer, COC entries will be made for all samples. Information on the labels will be checked against sample log entries, and sample tracking forms and samples will be recounted. COC forms will accompany all samples. The COC forms will be signed at each point of transfer. Copies of all COC forms will be retained and included as appendices to the data and analysis report.

The laboratory will ensure that COC forms are properly signed upon receipt of the samples and will note questions or observations concerning sample integrity on the COC forms. The laboratory will contact the project QA/QC coordinator immediately if discrepancies are discovered between the COC forms and the sample delivery upon receipt.

3.3.3 Shipping requirements and receipt

Coolers that contain samples for chemical analyses will be hand-delivered to ARI at the end of each day. The temperature of the samples will be checked with an infrared thermometer upon receipt of the coolers. The laboratory will specifically note any

coolers that do not contain ice packs or that are not sufficiently cold ($4^{\circ}\text{C} \pm 2^{\circ}\text{C}$) upon receipt.

Each sample will be assigned a unique laboratory number using ARI's laboratory information management system, which matches the sample ID with a laboratory ID and prints labels, which are then affixed to each sample. After the samples have been labeled, a second person will confirm that the sample ID matches the laboratory ID. The laboratory will ensure that a sample tracking record follows each sample through all stages of laboratory processing. The sample tracking record must contain, at a minimum, the name/initials of the individuals responsible for performing the analyses, dates of sample extraction/preparation and analyses, and the type of analysis being performed.

All samples will be handled so as to prevent contamination or loss of any sample. Samples will be assigned a specific storage area within the laboratory and will be kept there until analyzed. The laboratory will not dispose of the environmental samples or sample extracts for this project until notified to do so in writing by the Windward PM.

3.4 ANALYTICAL METHODS REQUIREMENTS

This section provides the selected analytical methods, sample handling requirements, and DQIs for laboratory.

3.4.1 Analytical methods and laboratory sample handling

The methods for chemical analysis and associated laboratory sample handling requirements are identified in Table 3-3.

Table 3-3. Laboratory analytical methods and sample handling requirements

Parameter	Analytical Method	Container	Filtration	Sample Preparation Method	Cleanup Method	Holding Time	Laboratory
VOCs	Purge and trap GC/MS (EPA 8260B)	3 40-mL vials with septa cap, preserved with hydrochloric acid	none	EPA SW5030B	none	14 days	ARI

GC/MS – gas chromatography/mass spectrometry

VOC – volatile organic compound

EPA – US Environmental Protection Agency

ARI – Analytical Resources, Inc.

3.4.2 Data quality indicators

The parameters used to assess data quality are precision, accuracy, representativeness, comparability, completeness, and sensitivity. Table 3-4 lists the DQIs for the analysis of VOCs. The MDL and RL values for each analyte are presented in Appendix C.

Table 3-4. Summary of DQIs for laboratory analyses

Parameter	Unit	Sensitivity		Precision ^a	Accuracy ^b	Completeness
		MDL	RL			
VOCs	µg/L	0.18 – 1.26	0.2-5.0	±30%	75 – 125%	95%

^a Precision is assessed through laboratory duplicate analyses (duplicate samples, MSDs, LCS duplicates).

^b Accuracy is assessed through the percent recoveries of MS, LCS, and surrogates.

DQI – data quality indicator

MSD – matrix spike duplicate

LCS – laboratory control sample

RL – reporting limit

MDL – method detection limit

VOC – volatile organic compound

MS – matrix spike

3.4.2.1 Precision

Precision is the measure of the reproducibility among individual measurements of the same property, usually under similar conditions, such as multiple measurements of the same sample. Precision is assessed by performing multiple analyses on a sample and is expressed as an RPD when duplicate analyses are performed and as a %RSD when more than two analyses are performed on the same sample (e.g., triplicates). Precision is assessed through laboratory duplicate analyses (duplicate samples, MSDs, LCS duplicates) for all parameters. Precision measurements can be affected by the nearness of a chemical concentration to the MDL, when the percent error (expressed as either %RSD or RPD) increases. The equations used to express precision are as follows:

$$RPD = \frac{|\text{measured conc} - \text{measured duplicate conc}|}{(\text{measured conc} + \text{measured duplicate conc}) \div 2} \times 100 \quad \text{Equation 1}$$

$$\%RSD = (SD/D_{ave}) \times 100 \quad \text{Equation 2}$$

where:

$$SD = \sqrt{\left(\frac{\sum (D_n - D_{ave})^2}{(n-1)} \right)}$$

D = sample concentration

D_{ave} = average sample concentration

n = number of samples

SD = standard deviation

3.4.2.2 Accuracy

Accuracy is an expression of the degree to which a measured or computed value represents the true value. Accuracy may be expressed as a percent recovery for surrogates, MS analyses, and LCS analyses. The equation used to express accuracy for spiked samples is as follows:

$$\text{Percent recovery} = \frac{\text{spike sample result} - \text{unspiked sample result}}{\text{amount of spike added}} \times 100 \quad \text{Equation 3}$$

3.4.2.3 Representativeness

Representativeness expresses the degree to which data accurately and precisely represent an environmental condition. The sampling approach was designed to address the specific objective described in Section 2.2.1.

3.4.2.4 Comparability

Comparability expresses the confidence with which one dataset can be evaluated in relation to another dataset. Therefore, the sample collection and chemical testing will adhere to the most recent PSEP QA/QC procedures (EPA 1999; PSEP 1997) and EPA and PSEP analysis protocols.

3.4.2.5 Completeness

Completeness is a measure of the amount of data that is determined to be valid in proportion to the amount of data collected. Completeness will be calculated as follows:

$$\text{Completeness} = \frac{\text{number of valid measurements}}{\text{total number of data points planned}} \times 100 \quad \text{Equation 4}$$

The DQI for completeness for all components of this project is 95%. Data that have been qualified as estimated because the QC criteria were not met will be considered valid for the purpose of assessing completeness. Data that have been qualified as rejected will not be considered valid for the purpose of assessing completeness.

3.4.2.6 Sensitivity

Analytical sensitivity is a measure of both the ability of the analytical method to detect the analyte and the concentration that can be reliably quantified. The minimum concentration of the analyte that can be detected is the MDL. The minimum concentration that can be reliably quantified is the RL. ARI uses both MDLs and RLs for reporting analyte concentrations. For this study, MDLs and RLs will be used as measures of sensitivity for each analysis. Non-detected results will be reported at the RL. Detected concentrations between the MDL and RL will be qualified as estimated by the laboratory (J-qualified).

3.5 QUALITY ASSURANCE/QUALITY CONTROL

3.5.1 Field quality control samples

Data validation guidelines have not been established for field QC samples. However, the data resulting from the analysis of field QA/QC samples is useful in identifying possible problems resulting from sample collection or sample processing in the field. All field QC samples will be documented in the field notebook and verified by the project QA/QC coordinator or a designee.

Field QA/QC samples will be used to evaluate the efficiency of collection equipment cleaning procedures, and variability attributable to sample handling conditions. Three types of field QA/QC samples will be collected during each sampling event: field replicates, trip blanks, and equipment blanks. These sample types are further described below. Locations for the collection of field QA/QC samples will be selected in the field by the FC.

3.5.1.1 Field replicate samples

One field replicate porewater sample will be collected from the same piezometer as the original sample at one sampling location and submitted for VOC analysis. The purpose of the field replicate is to evaluate variability attributable to field conditions and sample handling.

3.5.1.2 Trip blanks

Trip blanks will be used to determine whether VOCs are introduced into samples during holding, shipping, or storage prior to analysis. Trip blanks will consist of deionized water sealed in a VOC sample container by the analytical laboratory. Trip blanks will be transported from the laboratory to the field, will remain in the cooler during sampling, and then will be returned to the laboratory unopened for analysis. One trip blank will be included in each cooler.

3.5.2 Chemical analyses

Before analyzing the samples, the laboratory must provide written protocols for the analytical methods to be used, calculate MDLs for each analyte in each matrix of interest, and establish an initial calibration curve for all analytes. The laboratory must demonstrate their continued proficiency by participating in inter-laboratory comparison studies and through the repeated analysis of certified reference materials, calibration checks, laboratory reagent blanks, and spiked samples.

3.5.2.1 Determination of MDLs

The MDL is defined as the lowest concentration of an analyte or compound that a method can detect in either a sample or a blank with 99% confidence. The laboratory determines MDLs using standard procedures outlined in 40 CFR 136. In summary, seven replicate samples will be fortified at 1 to 5 times (but not to exceed 10 times) the

expected MDL concentration. The MDL is then determined by calculating the standard deviation of the replicates and multiplying by a factor of 3.14.

3.5.2.2 Sample delivery group

Project- and/or method-specific QC measures such as MS/MSDs will be analyzed per sample delivery group (SDG) or sample batch. An SDG is defined as no more than 20 samples or a group of samples received at the laboratory within a 2-week period. Although an SDG may span 2 weeks, all holding times specific to each analytical method will be met for each sample in the SDG.

3.5.2.3 Laboratory quality control criteria

The analyst will review the results of QC analyses (Table 3-5) for each sample group immediately after a sample group has been analyzed. The QC sample results will then be evaluated to determine whether control limits have been exceeded. If control limits have been exceeded in the sample group, the project QA/QC coordinator will be contacted immediately, and corrective action, such as method modifications followed by the reprocessing of the affected samples, will be initiated before a subsequent group of samples is processed.

Table 3-5. Laboratory quality control sample analysis summary

Analysis Type	Initial Calibration	Continuing Calibration	Matrix Spikes	Matrix Spike Duplicates	Method Blanks	Surrogate Spikes	Laboratory Control Samples
VOCs	prior to analysis	daily	one per batch or SDG	one per batch or SDG	each batch or SDG	each sample	one1 per batch or SDG

SDG – sample delivery group

VOC – volatile organic compound

All primary chemical standards and standard solutions used in this project will be traceable to the National Institute of Standards and Technology, Environmental Resource Associates, National Research Council of Canada, or other documented, reliable, commercial sources. The accuracy of the standards will be verified by comparison with an independent standard. Laboratory QC standards are verified in a multitude of ways. Second-source calibration verifications (i.e., same standard, two different vendors) are performed for calibrations. New working standard mixes (e.g., calibrations, spikes) are verified against the results of the original solution and must be within 10%. Newly purchased standards are verified against current data. Any impurities found in the standard will be documented. The following subsections summarize the procedures that will be used to assess data quality throughout sample analysis. Table 3-5 summarizes the QC samples to be analyzed by the laboratory.

Matrix Spikes and Matrix Spike Duplicates

The analysis of MS samples provides information on the efficiency of the purge and trap method and how it might be biased by the sample matrix. By performing duplicate

MS analyses, information on the precision of the method is also provided for organic analyses. A minimum of one MS/MSD will be analyzed for each sample group or for every 20 samples, whichever is more frequent, when possible.

Surrogate Spikes

All project samples analyzed will be spiked with appropriate surrogate compounds as defined in the analytical methods. Surrogate recoveries will be reported by the laboratory; however, no sample results will be corrected for recovery using these values.

Method Blanks

Method blanks are analyzed to assess possible laboratory contamination at all stages of sample preparation and analysis. A minimum of one method blank will be analyzed for each extraction batch or for every 20 samples, whichever is more frequent.

Laboratory Control Samples

LCS are analyzed as a measure of the accuracy of the analyses. LCS recoveries will be reported by the laboratories; however, sample results will not be corrected for recovery using these values.

3.6 FIELD AND LABORATORY INSTRUMENT/EQUIPMENT TESTING, INSPECTION, AND MAINTENANCE

The FC will be responsible for overseeing the testing, inspection, and maintenance of all field equipment. Prior to each field event, measures will be taken to test, inspect, and maintain all field equipment. All equipment used, including the GPS unit, digital camera, and multi-parameter probe (e.g., YSI- 6820 V2, Horiba U-22) with flow-through cell will be tested for use before leaving for the field event.

The laboratory PM will be responsible for ensuring that laboratory equipment testing, inspection, and maintenance requirements are met. The calibration methods used in calibrating the analytical instrumentation are described in Section 3.7.

3.7 INSTRUMENT CALIBRATION AND FREQUENCY

Multi-point initial calibration will be performed on each instrument at the start of the project, after each major power interruption to the analytical instrument, and when any continuing calibration does not meet the specified criteria. The number of points used in the initial calibration is defined in each analytical method. Continuing calibrations will be performed every 12 hours for VOC analyses.

Field equipment will be calibrated according to the instrument manual on each day of sampling prior to use in the field. Calibration will be checked no less frequently than specified in the instrument manual for the types of measurement being made and the conditions present. Calibration information will be recorded in the field notebook. Equipment will be handled according to manufacturer's recommendations. Unusual or

questionable readings will be noted, and duplicate readings made. Precision will be assessed by comparing the results from duplicate measurements, as discussed in Section 3.4.2.1.

The calibration of analytical equipment used for chemical analysis includes instrument blanks and continuing calibration blanks, which provide information on the stability of the established baseline. Continuing calibration blanks will be analyzed immediately after the continuing calibration verification at a frequency of one blank every 12 hours for VOC analyses. If the continuing calibration does not meet the specified criteria, the analysis must stop. Analysis may resume after corrective actions have been taken to meet the method specifications. All project samples analyzed by an instrument found to be out of compliance must be reanalyzed.

3.8 INSPECTION/ACCEPTANCE OF SUPPLIES AND CONSUMABLES

The FC will have a checklist of supplies required for each day in the field (see Section 3.2.4). The FC will gather and check these supplies daily to ensure that they are in satisfactory condition before each field event. Batteries used in the GPS unit and the digital camera will be checked daily and recharged as necessary. Sample containers will be inspected to ensure that they are the correct size and quantity and were not damaged in shipment.

3.9 DATA MANAGEMENT

All data will be recorded on field forms, which will be checked by the FC at the end of each field day. After sampling efforts are completed, all data from field forms will be entered into a Microsoft Excel® spreadsheet. A QC check will be done to ensure that all data were properly transferred from the field form to the spreadsheet (see Section 5.1). This spreadsheet will be kept on the Windward network drive, which is backed up daily. Field forms will be archived in the Windward library.

Analytical laboratories are expected to submit data in an electronic format as described in Section 2.6.2 and Table 2-2. The laboratory PM should contact the project QA/QC coordinator prior to data delivery to discuss specific format requirements.

Written documentation will be used to clarify how field and laboratory duplicates and QA/QC samples are recorded in the data tables. The data management task will include keeping accurate records of field and laboratory QA/QC samples so that project team members who use the data will have appropriate documentation. Data management files will be stored on a secure computer.

4 Assessment and Oversight

4.1 COMPLIANCE ASSESSMENTS AND RESPONSE ACTIONS

EPA, Ecology, or other management agencies may observe field activities during each sampling event, as needed. If situations in which there is an inability to follow QAPP methods precisely arise, the Windward PM will determine the appropriate actions or consult EPA and Ecology if the issue is significant.

4.1.1 Compliance assessments

Laboratory and field performance assessments consist of onsite reviews (conducted by EPA) of QA systems and equipment for sampling, calibration, and measurement. EPA personnel may conduct a laboratory audit prior to sample analysis. Any pertinent laboratory audit reports will be made available to the project QA/QC coordinator upon request. The laboratory is required to have written procedures that address internal QA/QC; these procedures will be submitted to the QA/QC manager for review to ensure compliance with the QAPP. The laboratory and QA/QC managers are required to ensure that all personnel engaged in sampling and analysis tasks have appropriate training.

4.1.2 Response actions for field sampling

The FC or a designee will be responsible for correcting equipment malfunctions throughout the field sampling effort and resolving situations in the field that may result in non-conformance or non-compliance with the QAPP. All corrective measures will be immediately documented in the field notebook, and Protocol Modification Forms (Form 2, Appendix B) will be completed.

4.1.3 Corrective action for laboratory analyses

The laboratory is required to comply with the standard operating procedures previously submitted to the project QA/QC coordinator. The laboratory PM will be responsible for ensuring that appropriate corrective actions are initiated as required for conformance with this QAPP. All laboratory personnel will be responsible for reporting problems that may compromise the quality of the data.

4.2 REPORTS TO MANAGEMENT

Progress reports will be prepared by the FC daily throughout the sampling event. The project QA/QC coordinator will also report to Project manager after the sampling has been completed and the samples have been submitted for analysis, and when the analysis is complete. The status of the samples and analysis will be summarized, with emphasis on any deviations from the QAPP. A data and analysis report will be written once validated data are available.

5 Data Validation and Usability

5.1 DATA VALIDATION

Data are not considered final until validated. Data validation will be conducted following EPA (1999) guidance. The data validation process begins in the laboratory. The laboratory analyst is responsible for ensuring that the analytical data are correct and complete, that appropriate procedures have been followed, and that QC results are within the acceptable limits. In addition, laboratory supervisory personnel or QA specialists review and evaluate data.

The project QA/QC coordinator is responsible for ensuring that all analyses performed by the laboratories are correct, properly documented, and complete and that they satisfy the DQO for this project, as specified in this QAPP.

Independent third-party data review and summary validation of the analytical chemical data will be conducted by Chris Ransom of EcoChem, Inc. (or a suitable alternative). The first SDG submitted to the laboratory will undergo full data validation. Full data validation parameters include:

- ◆ QC analysis frequencies
- ◆ COC and sample handling procedures
- ◆ Analysis holding times
- ◆ Laboratory blank contamination
- ◆ Instrument calibration
- ◆ Surrogate recoveries
- ◆ LCS recoveries
- ◆ MS recoveries
- ◆ MS/MSD RPDs
- ◆ Compound identifications – verification of raw data with the reported results (10% of samples)
- ◆ Compound quantitations – verification of calculations and RLs (10% of samples)
- ◆ Instrument performance check using ion abundances
- ◆ Internal standard areas and retention time shifts

If no discrepancies between reported results and raw data in the set that undergoes full data validation are found, then the validation of the subsequent SDGs will proceed as a summary validation, including an evaluation of all the summary forms for calibrations, instrument performance, and internal standard summaries. Data verification and validation will be conducted in accordance with EPA guidance (2002b), as well as the project's specified DQIs (Table 3-4), the technical specifications of the methods indicated

in Table 3-3, and EPA (1999, 2002c) guidance for organic data review. The EPA PM may have EPA peer review the third-party validation or perform data assessment/validation on a percentage of the data.

All discrepancies and requests for additional, corrected data will be discussed with the laboratory prior to the issuance of the formal data validation report. All contacts with the laboratory will be documented in a communication report. Review procedures used and findings made during data validation will be documented on worksheets.

EcoChem, Inc., will prepare a data validation report that lists the samples (using field sample IDs and corresponding laboratory IDs) and the suite of parameters evaluated and will provide a brief discussion of each data validation parameter, focusing on exceedances and out-of-control QC results and their effects on the quality of the data reported. Only validated data with appropriate qualifiers will be released for general use.

5.2 RECONCILIATION WITH DATA QUALITY OBJECTIVES

A data quality assessment will be conducted by the project QA/QC coordinator in consultation with EPA guidelines. The results of the third-party independent review and validation will be reviewed, and cases in which the project DQIs were not met will be identified. The usability of the data will be determined in terms of the magnitude of the DQI exceedance.

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**EAST WATERWAY OPERABLE UNIT
QUALITY ASSURANCE PROJECT PLAN:
POREWATER SAMPLING OF EAST WATERWAY
APPENDICES A – C**

For submittal to:

The US Environmental Protection Agency
Region 10
Seattle, WA

July 2010

Prepared by:



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Table of Contents

Appendix A. Health and Safety Plan	1
ACRONYMS	2
A.1 INTRODUCTION	3
A.2 SITE DESCRIPTION AND PROJECT SCOPE	3
A.2.1 Site Description	3
A.2.2 Scope and Duration of Work	4
A.3 HEALTH AND SAFETY PERSONNEL	4
A.4 HAZARD EVALUATION AND CONTROL MEASURES	4
A.4.1 Physical Hazards	5
A.4.1.1 <i>Slips, trips, and falls</i>	5
A.4.1.2 <i>Sampling equipment</i>	5
A.4.1.3 <i>Manual lifting</i>	5
A.4.1.4 <i>Heat stress, hypothermia, or frostbite</i>	6
A.4.1.5 <i>Weather</i>	6
A.4.1.6 <i>Sharp objects</i>	6
A.4.2 Chemical Hazards	6
A.4.2.1 <i>Exposure routes</i>	6
A.4.2.2 <i>Description of chemical hazards</i>	7
A.4.3 Activity Hazard Analysis	7
Table A-2. Activity hazard analysis	8
A.5 WORK ZONES	8
A.5.1 Work Zone	8
A.5.2 Decontamination Station	8
A.6 SAFE WORK PRACTICES	8
A.7 PERSONAL PROTECTIVE EQUIPMENT AND SAFETY EQUIPMENT	9
A.7.1 Level D Personal Protective Equipment	9
A.7.2 Modified Level D Personal Protective Equipment	9
A.8 MONITORING PROCEDURES FOR SITE ACTIVITIES	10
A.9 DECONTAMINATION	11
A.9.1 Minimization of Contamination	11
A.9.2 Personnel Decontamination	12
A.9.3 Sampling Equipment Decontamination	12
A.10 DISPOSAL OF CONTAMINATED MATERIALS	12
A.11 TRAINING REQUIREMENTS	12
A.11.1 Project-Specific Training	12
A.11.2 Daily Safety Briefings	13
A.11.3 First Aid and CPR	13
A.12 MEDICAL SURVEILLANCE	13
A.13 REPORTING AND RECORD KEEPING	14

A.14	EMERGENCY RESPONSE PLAN	14
A.14.1	Pre-emergency Preparation	15
A.14.2	Project Emergency Coordinator	15
A.14.3	Emergency Response Contacts	15
	Table A-3. Emergency response contacts	16
A.14.4	Recognition of Emergency Situations	16
A.14.5	Decontamination	16
A.14.6	Fire	16
A.14.7	Personal Injury	17
A.14.8	Overt Personal Exposure or Injury	18
	A.14.8.1 Skin contact	18
	A.14.8.2 Inhalation	18
	A.14.8.3 Ingestion	18
	A.14.8.4 Puncture wound or laceration	18
A.14.9	Spills and Spill Containment	18
A.14.10	Emergency Route to the Hospital	18
A15	REFERENCES	19
	ATTACHMENT A1. FIELD TEAM HEALTH AND SAFETY PLAN REVIEW	20
	Appendix B. Field Forms	21
	Form 1. Porewater Piezometer Collection Form	23
	Form 2. Protocol Modification Form	24
	Appendix C. Risk-Based Analytical Concentration Goals for VOCs in Porewater	25
	Table C-1. RBCs for freshwater and marine invertebrates from ECOTOX	26
	Table C-2. ACGs compared to RLs	32
	Table C-3. List of MDLs and RLs for entire list of VOCs as reported by ARI using EPA Method 8260B	33
	References	35

APPENDIX A. HEALTH AND SAFETY PLAN

By their signature, the undersigned certify that this Health and Safety Plan (HSP) is approved and that it will be used to govern health and safety aspects of fieldwork described in the Quality Assurance Project Plan to which it is attached.

Name

Windward Project Manager

Date

Name

Corporate Health and Safety Manager

Date

Name

Field Coordinator/Health and Safety Officer

Date

Acronyms

Acronym	Definition
CPR	cardiopulmonary resuscitation
CSO	combined sewer overflow
EPA	US Environmental Protection Agency
FC	field coordinator
GPS	global positioning system
HSM	Project Health and Safety Manager
HSO	Field Health and Safety Officer
HSP	health and safety plan
OSHA	Occupational Safety and Health Administration
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyls
PEC	project emergency coordinator
PPE	personal protective equipment
PM	project manger
QAPP	Quality Assurance Project Plan
TM	task manager
TBT	tributyltin

A.1 Introduction

This site-specific health and safety plan (HSP) describes safe working practices for conducting field activities at potentially hazardous sites and for handling potentially hazardous materials/waste products. This HSP covers elements as specified in 29CFR1910§120. The procedures and guidelines contained in this plan are based on generally recognized health and safety practices. Any changes or revisions to this plan will be made by a written amendment, which will become a permanent part of this plan. The goal of the HSP is to establish procedures for safe working practices for all field personnel.

This HSP addresses all activities associated with collection and handling of porewater samples in the East Waterway (EW). During site work, this HSP will be implemented by Windward's Field Coordinator (FC), who is also the designated site Health and Safety Officer (HSO), in cooperation with Windward's Corporate Health and Safety Manager (HSM) and Windward's Project Manager (PM).

All personnel involved in fieldwork on this project are required to comply with this HSP. The contents of this HSP reflect anticipation of the types of activities to be performed, knowledge of the physical characteristics of the site, and consideration of preliminary chemical data from previous investigations at the site. The HSP may be revised based on new information and/or changed conditions during site activities. Revisions will be documented in the project records.

Observers for the porewater sampling event who are not field personnel will be given a safety briefing by the HSO on physical and chemical hazards. Observers will be advised of chemicals that may be present at the site and where those chemicals may be located. In addition, appropriate attire and any precautions necessary while walking along the shoreline will be discussed.

A.2 Site Description and Project Scope

A.2.1 SITE DESCRIPTION

The sampling area is in the EW (see Figure 2-1 in the attached QAPP). The area is affected by tidal fluctuations. The QAPP to which this HSP is attached provides complete details of the sampling program. The following section summarizes the types of work that will be performed during field activities.

A.2.2 SCOPE AND DURATION OF WORK

Porewater samples will be collected with mini piezometers from select locations for chemical analysis. Mini piezometers will be deployed following approval of the QAPP. Intertidal porewater sampling locations will be accessed by land.

A.3 Health and Safety Personnel

Key health and safety personnel and their responsibilities are described below. These individuals are responsible for the implementation of this HSP.

Task Manager: The task manager (TM) has overall responsibility for the successful outcome of the project. The TM will ensure that adequate resources and budget are provided for the health and safety staff to carry out their responsibilities during fieldwork. The TM, in consultation with the HSM, makes final decisions concerning implementation of the HSP.

Field Coordinator/Health and Safety Officer: Because of the limited scope and duration of fieldwork, the FC and HSO will be the same person. The FC/HSO will direct field sampling activities, coordinate the technical components of the field program with health and safety components, and ensure that work is performed according to the QAPP.

The FC/HSO will implement this HSP at the work location and will be responsible for all health and safety activities and the delegation of duties to a health and safety technician in the field, if appropriate. The FC/HSO also has stop-work authority, to be used if there is an imminent safety hazard or potentially dangerous situation. The FC/HSO or his designee shall be present during sampling and operations.

Windward's Corporate Health and Safety Manager: The HSM has overall responsibility for preparation, approval, and revisions of this HSP. The HSM will not necessarily be present during fieldwork, but will be readily available, if required, for consultation regarding health and safety issues during fieldwork.

Field Crew: All field crew members must be familiar with and comply with the information in this HSP. They also have the responsibility to report any potentially unsafe or hazardous conditions to the FC/HSO immediately.

A.4 Hazard Evaluation and Control Measures

This section covers potential physical and chemical hazards that may be associated with the proposed project activities, and presents control measures for addressing these hazards. The activity hazard analysis, Section A.4.3, lists the potential hazards associated with each site activity and the recommended site controls to be used to minimize each potential hazard.

Confined space entry will not be necessary for this project. Therefore, hazards associated with this activity are not discussed in this HSP.

A.4.1 PHYSICAL HAZARDS

For this project, it is anticipated that physical hazards will present a greater risk of injury than chemical hazards. Physical hazards are identified and discussed below.

A.4.1.1 Slips, trips, and falls

As with all fieldwork sites, caution should be exercised to prevent slips, trips, and falls on slick or uneven surfaces. In particular, care should be used in rainy conditions, on the shoreline, and when getting on or off the boat to access the shoreline. Debris, including slick rocks, pieces of wood or pilings, vegetation, and other objects, are found along the shoreline throughout the EW. Before sampling activities begin, there will be a training session for all field personnel on the physical hazards to be aware of both on the boat and on shore.

Slips can be minimized by wearing boots with good tread, made of material that does not become overly slippery when wet. Trips are always a hazard on the uneven deck of a boat, in a cluttered work area, or in the intertidal zone where uneven substrate is common. Personnel will keep work areas as free as possible from items that interfere with walking. Falls may be avoided by working as far from exposed edges as possible, by erecting railings, and by using fall protection when working on elevated platforms. For this project, no work is anticipated that would present a fall hazard.

A.4.1.2 Sampling equipment

Sampling equipment, including GPS, Hydrolab, piezometers, syringes and digital cameras, may be used. The sampling methodologies are not anticipated to be labor intensive; however, care will be taken to ensure safe use of all equipment. Before field activities begin, there will be a training session for all field personnel in use of sampling equipment.

A.4.1.3 Manual lifting

Equipment and samples must be lifted and carried. Back strain can result if lifting is done improperly. During any manual handling tasks, personnel should lift with the load supported by their legs and not their backs. For heavy loads, an adequate number of people will be used, or if possible, a mechanical lifting/handling device will be used.

A.4.1.4 Heat stress, hypothermia, or frostbite

Sampling operations and conditions that might result in the occurrence of heat stress, hypothermia, or frostbite are not anticipated. The sampling will occur during the time of year when extreme weather conditions are not expected to occur.

A.4.1.5 Weather

In general, field team members will be equipped for the normal range of weather conditions. The FC/HSO will be aware of current weather conditions, and of the potential for those conditions to pose a hazard to the field crew. Some conditions that might force work stoppage are electrical storms, high winds, or high waves resulting from winds.

In the event of heavy rain, field team members will not sample near a flowing CSO because of potentially high concentrations of fecal coliform bacteria.

A.4.1.6 Sharp objects

Sampling operations might result in exposure of field personnel to sharp objects on top of or buried within the sediment. If encountered, field personnel should not touch these objects. Also, field personnel should use a shovel or other tool and not dig in the sediment by hand.

A.4.2 CHEMICAL HAZARDS

Previous investigations have shown that some chemical substances are present at higher-than-background concentrations in the sampling area. For the purpose of a discussion on potential exposure to these chemicals in water, the chemicals of concern are metals, tributyltin, polycyclic aromatic hydrocarbons (PAHs), and polychlorinated biphenyls (PCBs).

A.4.2.1 Exposure routes

Potential routes of chemical exposure include inhalation, dermal contact, and ingestion. Exposure will be minimized by using safe work practices and by wearing the appropriate personal protective equipment (PPE). Further discussion of PPE requirements is presented in Section A.6.

Inhalation —Inhalation is not expected to be an important route of exposure because work is being performed outdoors.

Dermal exposure — Dermal exposure to hazardous substances associated with sediments, surface water, or equipment decontamination will be controlled by the use of PPE and by adherence to detailed sampling and decontamination procedures.

Ingestion — Ingestion is not considered a major route of exposure for this project. Accidental ingestion of surface water is possible. However, careful handling of equipment and containers on board the boat should prevent the occurrence of water splashing or spilling during sample collection and handling activities.

A.4.2.2 Description of chemical hazards

Metals and tributyltin — Exposure to metals can occur via ingestion or skin contact. As mentioned above, neither is a likely exposure route for this project. Metal fumes or metal-contaminated dust will not be encountered during field and sample handling activities. Large amounts of water would need to be ingested for any detrimental effects to occur. Momentary skin contact allows little, if any, opportunity for the passage of any of the metals into the body.

Petroleum hydrocarbons and PAHs — Exposure to PAHs can occur via ingestion or skin contact. The most important human health exposure pathway (inhalation) for this group of chemicals is not expected to be significant at this site. Animal studies have shown that PAHs can cause harmful effects on skin, body fluids, and the ability to fight disease after both short- and long-term exposure, but these effects have not been documented in people. Some PAHs may reasonably be expected to be carcinogens. Large amounts of water would need to be ingested for any detrimental effects to occur. Momentary skin contact allows little, if any, opportunity for the passage of any of the compounds into the body.

Polychlorinated biphenyls — Prolonged skin contact with PCBs can cause acne-like symptoms known as chloracne. Irritation to eyes, nose, and throat can also occur. Acute and chronic exposure can damage the liver and cause symptoms of edema, jaundice, anorexia, nausea, abdominal pains, and fatigue. PCBs are a suspected human carcinogen. Skin absorption can substantially contribute to the uptake of PCBs. Momentary skin contact allows little, if any, opportunity for the passage of any of these compounds into the body. Large amounts of water would need to be ingested for any detrimental effects to occur.

A.4.3 ACTIVITY HAZARD ANALYSIS

The activity hazard analysis summarizes the field activities to be performed during the project, outlines the hazards associated with each activity, and presents controls that can reduce or eliminate the risk of the hazard occurring.

Table A-2 presents the activity hazard analysis for the porewater sampling activities.

Table A-2. Activity hazard analysis

Activity	Hazard	Control
Accessing shoreline	Slips, trips, or falls	Be cognizant of obstacles on shore.
Porewater sampling	Skin contact with contaminated sediment or porewater; contact with sharp objects	Wear modified Level D PPE or diving suit and gear. Do not dig in sediment with hands. Do not touch sharp objects if found.

PPE – personal protective equipment

A.5 Work Zones

During sampling and sample handling activities, work zones will be established to identify where sample collection and processing are actively occurring. The intent of the work zone is to limit the migration of sample material out of the work zone and to restrict access to active work areas by defining work zone boundaries.

A.5.1 WORK ZONE

The work zones onshore will encompass the area where sample collection and handling activities are performed. On the beach, the FC/HSO will delineate the work zone as a particular area. Only persons with appropriate training, PPE, and authorization from the FC/HSO will be allowed to enter the work zone while work is in progress.

A.5.2 DECONTAMINATION STATION

A decontamination station will be set up at the end of a work day for personnel to clean PPE and equipment. The station will have the buckets, brushes, soapy water, rinse water, or wipes necessary to clean boots, PFDs, dive gear, or other PPE and equipment. Plastic bags will be provided for expendable and disposable materials.

A.6 Safe Work Practices

Following common sense rules will minimize the risk of exposure or accidents at a work site. These general safety rules will be followed on site:

- ◆ Do not climb over or under obstacles of questionable stability.
- ◆ Do not eat, drink, smoke, or perform other hand-to-mouth transfers in the work zone.
- ◆ Work only in well-lighted spaces.
- ◆ Never enter a confined space without the proper training, permits, and equipment.
- ◆ Get immediate first aid for all cuts, scratches, abrasions, or other minor injuries.

- ◆ Use the established sampling and decontamination procedures.
- ◆ Always use the buddy system.
- ◆ Be alert to your own and other workers' physical condition.
- ◆ Report all accidents, no matter how minor, to the FC/HSO.
- ◆ Do not do anything dangerous or unwise even if ordered by a supervisor.

A.7 Personal Protective Equipment and Safety Equipment

Appropriate PPE will be worn as protection against potential hazards. Prior to donning PPE, the field crew will inspect their PPE for any defects that might render the equipment ineffective.

Fieldwork will be conducted in Level D or modified Level D PPE, as discussed below in Sections A.7.1 and A.7.2. Situations requiring PPE beyond modified Level D are not anticipated. Should the FC/HSO determine that PPE beyond modified Level D is necessary, the HSM will be notified and an alternative selected.

A.7.1 LEVEL D PERSONAL PROTECTIVE EQUIPMENT

Workers performing general activities in which skin contact with contaminated materials is unlikely will wear Level D PPE. Level D PPE includes the following:

- ◆ Cotton overalls or laboratory coats
- ◆ Chemical-resistant steel-toed boots
- ◆ Chemical-resistant gloves
- ◆ Safety glasses

A.7.2 MODIFIED LEVEL D PERSONAL PROTECTIVE EQUIPMENT

Workers performing activities where skin contact with contaminated materials is possible and in which inhalation risks are not expected will be required to wear an impermeable outer suit. The type of outerwear will be chosen according to the types of chemical contaminants that might be encountered. Modified Level D PPE includes the following:

- ◆ Impermeable outer garb such as rain gear
- ◆ Chemical-resistant steel-toed boots
- ◆ Chemical-resistant outer gloves

A.8 Monitoring Procedures for Site Activities

A monitoring program that addresses the potential site hazards will be maintained. For this project, air, dust, and noise monitoring will not be necessary. The sampled media will be wet and will not pose a dust hazard, and none of the equipment emits high-amplitude (>85 dBA) sound. For this project, the monitoring program will consist of all workers monitoring themselves and their co-workers for signs that might indicate physical stress or illness.

All personnel will be instructed to look for and inform each other of any deleterious changes in their physical or mental condition during the performance of all field activities. Examples of such changes are as follows:

- ◆ Headaches
- ◆ Dizziness
- ◆ Nausea
- ◆ Symptoms of heat stress
- ◆ Blurred vision
- ◆ Cramps
- ◆ Irritation of eyes, skin, or respiratory system
- ◆ Changes in complexion or skin color
- ◆ Changes in apparent motor coordination
- ◆ Increased frequency of minor mistakes
- ◆ Excessive salivation or changes in papillary response
- ◆ Changes in speech ability or speech pattern
- ◆ Shivering
- ◆ Blue lips or fingernails
- ◆ Loss of communication with diver

If any of these conditions develop, work shall be halted immediately and the affected person(s) evaluated. If further assistance is needed, personnel at the local hospital will be notified, and an ambulance will be summoned if the condition is thought to be serious. If the condition is the direct result of sample collection or handling activities, procedures will be modified to address the problem.

A.9 Decontamination

Decontamination is necessary to prevent the migration of contaminants from the work zone(s) into the surrounding environment and to minimize the risk of exposure of personnel to contaminated materials that might adhere to PPE. The following sections discuss personnel and equipment decontamination. The following supplies will be available to perform decontamination activities:

- ◆ Wash buckets
- ◆ Rinse buckets
- ◆ Long-handled scrub brushes
- ◆ Clean water sprayers
- ◆ Paper towels
- ◆ Plastic garbage bags
- ◆ Alconox® or similar decontamination solution

A.9.1 MINIMIZATION OF CONTAMINATION

The first step in addressing contamination is to prevent or minimize exposure to existing contaminated materials and the spread of those materials. During field activities, the FC/HSO will enforce the following measures:

Personnel:

- ◆ Do not walk through areas of obvious or known contamination
- ◆ Do not handle, touch, or smell contaminated materials directly
- ◆ Make sure PPE has no cuts or tears prior to use
- ◆ Fasten all closures on outer clothing, covering with tape if necessary
- ◆ Protect and cover any skin injuries
- ◆ Stay upwind of airborne dusts and vapors
- ◆ Do not eat, drink, chew tobacco, or smoke in the work zones

Sampling equipment and boat:

- ◆ Place clean equipment on a plastic sheet to avoid direct contact with contaminated media
- ◆ Keep contaminated equipment and tools separate from clean equipment and tools

A.9.2 PERSONNEL DECONTAMINATION

The FC/HSO will ensure that all site personnel are familiar with personnel decontamination procedures. Personnel will perform decontamination procedures, as appropriate, before eating lunch, taking a break, or before leaving the work location. Following is a description of these procedures.

Decontamination procedure:

1. If outer suit is heavily soiled, rinse it off
2. Wash and rinse outer gloves and boots with water
3. Remove outer gloves; inspect and discard if damaged
4. Wash hands if taking a break
5. Don necessary PPE before returning to work
6. Dispose of soiled, expendable PPE before leaving for the day

A.9.3 SAMPLING EQUIPMENT DECONTAMINATION

All equipment for porewater collection will be decontaminated before each use by rinsing with EW water, washing with detergent such as Alconox, and then rinsed with EW water.

A.10 Disposal of Contaminated Materials

All disposable sampling materials and PPE, such as disposable coveralls, gloves, and paper towels used in sample processing, will be placed in heavyweight garbage bags. Filled garbage bags will be placed in a normal refuse container for disposal as solid waste.

A.11 Training Requirements

Individuals performing work at locations where potentially hazardous materials and conditions may be encountered must meet specific training requirements. It is not anticipated that hazardous concentrations of contaminants will be encountered in sampled material, so training will consist of site-specific instruction for all personnel and oversight of inexperienced personnel by an experienced person for one working day. The following sections describe the training requirements for this fieldwork.

A.11.1 PROJECT-SPECIFIC TRAINING

In addition to HAZWOPER training, as described in Section 2.5 of the QAPP, field personnel will undergo training specifically for this project. All personnel must read

this HSP and be familiar with its contents before beginning work. They shall acknowledge reading the HSP by signing the field team HSP review form contained in Attachment A1. The completed form will be kept in the project files.

Field personnel will not be allowed to begin work until project-specific training is completed and documented by the FC/HSO. Training will address the HSP and all health and safety issues and procedures pertinent to field operations. Training will include, but not be limited to, the following topics:

- ◆ Activities with the potential for chemical exposure
- ◆ Activities that pose physical hazards, and actions to control the hazard
- ◆ Use and limitations of PPE
- ◆ Decontamination procedures
- ◆ Emergency procedures
- ◆ Use and hazards of sampling equipment

A.11.2 DAILY SAFETY BRIEFINGS

The FC/HSO or a designee will present safety briefings before the start of each day's activities. These safety briefings will outline the activities expected for the day, update work practices and hazards, address any specific concerns associated with the work location, and review emergency procedures and routes. The FC/HSO or designee will document safety briefings in the logbook.

A.11.3 FIRST AID AND CPR

At least one member of the field team must have first-aid and cardiopulmonary resuscitation (CPR) training. Documentation of which individuals possess first-aid and CPR training will be kept in the project health and safety files.

A.12 Medical Surveillance

A medical surveillance program conforming to the provisions of 29CFR1910§120(f) is not necessary for field team members because they do not meet any of the four criteria outlined in the regulations for implementation of a medical surveillance program:

- ◆ Employees who are or may be exposed to hazardous substances or health hazards at or above permissible exposure levels for 30 days or more per year (1910.120(f)(2)(I))
- ◆ Employees who must wear a respirator for 30 days or more per year (1910.120(f)(2)(ii))

- ◆ Employees who are injured or become ill as a result of possible overexposures involving hazardous substances or health hazards from an emergency response or hazardous waste operation (1910.120(f)(2)(iii))
- ◆ Employees who are members of HAZMAT teams (1910.120(f)(2)(iv)).

As described in Section A.8, employees will monitor themselves and each other for any deleterious changes in their physical or mental condition during the performance of all field activities.

A.13 Reporting and Record Keeping

Each member of the field crew will sign the HSP review form (see Attachment A1). If necessary, accident/incident report forms and Occupational Safety and Health Administration (OSHA) Form 200s will be completed by the FC/HSO.

The FC/HSO or a designee will maintain a health and safety field logbook that records health- and safety-related details of the project. Alternatively, entries may be made in the field logbook, in which case a separate health and safety logbook will not be required. The logbook must be bound and the pages must be numbered consecutively. Entries will be made with indelible blue ink. At a minimum, each day's entries must include the following information:

- ◆ Project name or location
- ◆ Names of all personnel on board
- ◆ Weather conditions
- ◆ Type of fieldwork being performed

The person maintaining the entries will initial and date the bottom of each completed page. Blank space at the bottom of an incompletely filled page will be lined out. Each day's entries will begin on the first blank page after the previous workday's entries.

A.14 Emergency Response Plan

As a result of the hazards and the conditions under which operations will be conducted, the potential exists for an emergency situation to occur. Emergencies may include personal injury, exposure to hazardous substances, fire, explosion, or release of toxic or non-toxic substances (spills). OSHA regulations require that an emergency response plan be available to guide actions in emergency situations.

Onshore organizations will be relied upon to provide response in emergency situations. The local fire department and ambulance service can provide timely response. Field personnel will be responsible for identifying an emergency situation, providing first aid

if applicable, notifying the appropriate personnel or agency, and evacuating any hazardous area.

The following sections identify the individual(s) who should be notified in case of emergency, provide a list of emergency telephone numbers, offer guidance for particular types of emergencies, and provide directions to a hospital from any sampling location.

A.14.1 PRE-EMERGENCY PREPARATION

Before the start of field activities, the FC/HSO will ensure that preparation has been made in anticipation of emergencies. Preparatory actions include the following:

- ◆ Meeting with the FC/HSO and equipment handlers concerning the emergency procedures to be followed in the event of an injury
- ◆ Conducting a training session informing all field personnel of emergency procedures, locations of emergency equipment and their use, and proper evacuation procedures
- ◆ Conducting a training session (led by senior staff responsible for operating field equipment) to apprise field personnel of operating procedures and specific risks associated with field equipment
- ◆ Ensuring that field personnel are aware of the existence of the emergency response plan in the HSP and ensuring that a copy of the HSP accompanies the field team

A.14.2 PROJECT EMERGENCY COORDINATOR

The FC/HSO will serve as the Project Emergency Coordinator (PEC) in the event of an emergency. She will designate her replacement for times when she is not available or is not serving as the PEC. The designation will be noted in the logbook. The PEC will be notified immediately when an emergency is recognized. The PEC will be responsible for evaluating the emergency situation, notifying the appropriate emergency response units, coordinating access with those units, and directing interim actions before the arrival of emergency response units. The PEC will notify the HSM and the Windward PM as soon as possible after initiating an emergency response action. The Windward PM will have responsibility for notifying the client.

A.14.3 EMERGENCY RESPONSE CONTACTS

All personnel must know whom to notify in the event of an emergency situation, even though the FC/HSO has primary responsibility for notification. Table A-3 lists the names and phone numbers for emergency response services and individuals.

Table A-3. Emergency response contacts

Contact	Telephone Number
Emergency Numbers	
Ambulance	911
Police	911
Fire	911
Harborview Medical Center	(206) 323-3074
Emergency Responders	
US Coast Guard	
Office	(206) 286-5400
Emergency	(206) 442-5295
General information	UHF Channel 16
National Response Center	(800) 424-8802
EPA	(908) 321-6660
Washington State Department of Ecology – Northwest Region Spill Response (24-hour emergency line)	(206) 649-7000
Emergency Contacts	
Susan McGroddy, Project Manager	(206) 812-5421
Tad Deshler, Corporate Health and Safety Manager	(206) 812-5406
Sarah Fowler, Field Coordinator/ Health and Safety Officer	(206) 353-9346 (site cellular telephone)

A.14.4 RECOGNITION OF EMERGENCY SITUATIONS

Emergency situations will generally be recognizable by observation. An injury or illness will be considered an emergency if it requires treatment by a medical professional and cannot be treated with simple first-aid techniques.

A.14.5 DECONTAMINATION

In the case of evacuation, decontamination procedures will be performed only if doing so does not further jeopardize the welfare of site workers. If an injured individual is also heavily contaminated and must be transported by emergency vehicle, the emergency response team will be told of the type of contamination. To the extent possible, contaminated PPE will be removed, but only if doing so does not exacerbate the injury. Plastic sheeting will be used to reduce the potential for spreading contamination to the inside of the emergency vehicle.

A.14.6 FIRE

Field personnel will attempt to control only small fires, should they occur. If an explosion appears likely, personnel will follow evacuation procedures specified during

the training session. If a fire cannot be controlled with a fire extinguisher on board that is part of the required safety equipment, personnel will either withdraw from the vicinity of the fire or evacuate the boat as specified in the training session.

A.14.7 PERSONAL INJURY

In the event of serious personal injury, including unconsciousness, possibility of broken bones, severe bleeding or blood loss, burns, shock, or trauma, the first responder will immediately do the following:

- ◆ Administer first aid, if qualified
- ◆ If not qualified, seek out an individual who is qualified to administer first aid, if time and conditions permit
- ◆ Notify the PEC of the incident, the name of the individual, the location, and the nature of the injury

The PEC will immediately do the following:

- ◆ Notify the appropriate emergency response organization.
- ◆ Assist the injured individual.
- ◆ Follow the emergency procedures for retrieving or disposing equipment reviewed in the training session and leave the site en route to the predetermined land-based emergency pick-up.
- ◆ Designate someone to accompany the injured individual to the hospital.
- ◆ If a life-threatening emergency occurs, i.e., injury where death is imminent without immediate treatment, the FC/HSO will call 911 and arrange to meet the Medic One unit at the nearest location. Otherwise, for emergency injuries that are not life-threatening (i.e., broken bones, minor lacerations, etc.) the PEC will follow the procedures outlined above and proceed to an alternative location of her choice if that would be more expedient.
- ◆ Notify the HSM and the Windward PM.

If the PEC determines that emergency response is not necessary, she may direct someone to decontaminate and transport the individual by vehicle to the nearest hospital. Directions showing the route to the hospital are in Section A.14.10.

If a worker leaves to seek medical attention, another worker should accompany them to the hospital. When in doubt about the severity of an injury or exposure, always seek medical attention as a conservative approach, and notify the Project Emergency Coordinator.

The PEC will have responsibility for completing all accident/incident field reports, OSHA Form 200s, and other required follow-up forms.

A.14.8 OVERT PERSONAL EXPOSURE OR INJURY

If an overt exposure to toxic materials occurs, the first responder to the victim will initiate actions to address the situation. The following actions should be taken, depending on the type of exposure.

A.14.8.1 Skin contact

- ◆ Wash/rinse the affected area thoroughly with copious amounts of soap and water
- ◆ If eye contact has occurred, eyes should be rinsed for at least 15 minutes using the eyewash that is part of the emergency equipment on board
- ◆ After initial response actions have been taken, seek appropriate medical attention

A.14.8.2 Inhalation

- ◆ Move victim to fresh air
- ◆ Seek appropriate medical attention

A.14.8.3 Ingestion

- ◆ Seek appropriate medical attention

A.14.8.4 Puncture wound or laceration

- ◆ Seek appropriate medical attention

A.14.9 SPILLS AND SPILL CONTAINMENT

No bulk chemicals or other materials subject to spillage are expected to be used during this project. Accordingly, no spill containment procedure is required for this project.

A.14.10 EMERGENCY ROUTE TO THE HOSPITAL

The name, address, and telephone number of the hospital that will be used to provide medical care is as follows:

Harborview Medical Center
325 Ninth Ave.
Seattle, WA
(206) 323-3074

Directions from the vicinity of EW to Harborview Medical Center are as follows:

- ◆ Drive north on E Marginal Way S

- ◆ Continue onto Alaskan Way
- ◆ Turn right at Yesler Way
- ◆ Turn left at 8th Ave
- ◆ Turn left on 9th Avenue to the emergency entrance

A15 References

PSEP. 1997. Recommended guidelines for sampling marine sediment, water column, and tissue in Puget Sound. Final Report. Prepared for the U.S. Environmental Protection Agency, Seattle, Washington, and the Puget Sound Water Quality Action Team, Olympia, WA.

Attachment A1. Field Team Health and Safety Plan Review

I have read a copy of the Health and Safety Plan, which covers field activities that will be conducted to investigate potentially contaminated areas in the EW. I understand the health and safety requirements of the project, which are detailed in this Health and Safety Plan.

Signature

Date

Signature

Date

Signature

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APPENDIX B. FIELD FORMS

FORM 1. POREWATER PIEZOMETER COLLECTION FORM

Project Name: _____ Project Task: _____

Date: _____ Crew: _____

Weather: _____ Collection Method: Piezometer

Location ID:		Easting (x):		Northing (y):		Time:	
Temp	SpC	DO	pH	ORP	Salinity		
1	1	1	1	1	1		
2	2	2	2	2	2		
Comments:							

Location ID:		Easting (x):		Northing (y):		Time:	
Temp	SpC	DO	pH	ORP	Salinity		
1	1	1	1	1	1		
2	2	2	2	2	2		
Comments:							

Location ID:		Easting (x):		Northing (y):		Time:	
Temp	SpC	DO	pH	ORP	Salinity		
1	1	1	1	1	1		
2	2	2	2	2	2		
Comments:							

FORM 2. **PROTOCOL MODIFICATION FORM**

Project Name and Number: _____

Material to be Sampled: _____

Measurement Parameter: _____

Standard Procedure for Field Collection & Laboratory Analysis (cite reference):

Reason for Change in Field
Procedure or Analysis Variation: _____

Variation from Field or
Analytical Procedure: _____

Special Equipment, Materials
or Personnel Required: _____

Initiator's
Name: _____ Date: _____

Project Officer: _____ Date: _____

QA Officer: _____ Date: _____

APPENDIX C. RISK-BASED ANALYTICAL CONCENTRATION GOALS FOR VOCs IN POREWATER

This appendix addresses the following question:

Are standard analytical methods proposed for VOC analysis of porewater samples sufficiently sensitive to assess risks to benthic organisms from exposure to porewater?

To answer this question, laboratory reporting limits (RLs) were compared to analytical concentration goals (ACGs) for water to ensure that the RLs are sufficiently low. To determine ACGs for this quality assurance project plan (QAPP), risk-based concentrations (RBCs) in water were derived for the protection of benthic invertebrates.

There are no federal or state water quality criteria for VOCs for the protection of aquatic organisms (EPA 2002; WAC 173-201A). Thus, individual toxicity study results reported in EPA's ECOTOX database were used to derive chemical-specific RBCs for VOCs that have been detected in groundwater or seeps adjacent to the EW (see Section 2.2 of this QAPP). Chemical-specific RBCs were derived for growth, mortality (including immobilization), reproductive, or developmental endpoints only. Data for invertebrate species only were searched, but if no invertebrate data were available, then data for fish were included. Toxicity data for marine species were included in the search because of the salinity range in the EW.

Note that the primary literature was not obtained for this screening exercise. For the technical memorandum discussed above, the data and analysis report, and the ERA, the search will be refined and the relevant primary literature will be obtained for derivation of TRVs for any chemicals identified as chemicals of interest based on the porewater results (see Sections 3.1.2.3 and 3.1.3.3 of the QAPP).

Table C-1 present the results of the ECOTOX search. Each row presents the minimum and maximum concentration (if available) reported in ECOTOX for a given chemical for a given species for similar endpoints. No toxicity data were available in ECOTOX for two chemicals—1,1-dichloroethane and chloroethane. The only toxicity data available for vinyl chloride in ECOTOX was for northern pike. Therefore, a detailed literature search was conducted for vinyl chloride and 1,1-dichloroethane, because these two chemicals were previously detected in groundwater or seeps from GWI or Boeing Plant 2/Jorgensen. Chloroethane was not previously detected in seeps or groundwater, so it was not included in the detailed literature search. One fish study was found for 1,1-dichloroethane (Könemann 1981) and one additional fish study was found for vinyl chloride [Groeneveld et al. (1993) as cited in de Rooij et al. (2004)]; Table C-1].

The lowest effect or no-effect concentration reported in ECOTOX was selected as the RBC, as shown in bold in Table C-1.

Table C-1. RBCs for freshwater and marine invertebrates from ECOTOX

Analyte	Minimum Reported Concentration ^a (µg/L)	Maximum Reported Concentration (µg/L)	Study Description
1,1,1-Trichloroethane	1,300		NOEC (mortality and reproduction), 17 days, <i>Daphnia magna</i>
	5,256	137,970	LC50, 24h, <i>Artemia salina</i>
	5,400	>1,300,000	LC50, 24h-17d, <i>Daphnia magna</i>
	9,850		LC50, 24h, fairy shrimp
	31,200		LC50, 96h, <i>Americamysis bahia</i> (opossum shrimp)
	530,000		LC50, 48h, <i>Daphnia magna</i>
	4,020,840		LC50, 24h, <i>Artemia salina</i>
	6,417,502		LC50, 24h, rotifer
1,1,2-Trichloroethane	1,000		NOEC (mortality), 48h, <i>Daphnia magna</i>
	10,000		mortality and growth, ^b 16d, great pond snail
	10,000		reproduction, ^b 3 wk, <i>Artemia bahia</i>
	15,000		EC50 (reproduction), 3wk, <i>Artemia salina</i>
	18,000	190,000	LC50, 24h-7d, <i>Daphnia magna</i>
	36,000	72,000	LC50, 48h-3 wk, <i>Artemia salina</i>
	18,000	42,000	reproduction, ^b 3-28d, <i>Daphnia magna</i>
	<31,000		NOEC (mortality), 48h, <i>Chironomus</i>
	36,000		EC50 (mortality and growth), 16d, great pond snail
	41,000	82,000	LC50, 48hr-3wk, amphipod
	42,000	43,000	LC50, 6h-7d, <i>Crangon crangon</i>
	43,000		LC50, 6h-7d, <i>Palaemonetes varians</i> (shrimp)
	43,000		LC50, 96h, calanoid copepod
	50,000	150,000	mortality, ^b 15d, polychaete
	58,000	170,000	LC50, 96h-16d, great pond snail
	65,000	110,000	LC50, 96h-14d, blue mussel
	140,000	320,000	LC50, 96h-14d, Zebra mussel
	147,000		LC50, 48h, <i>Chironomus</i>
	160,000	500,000	LC50, 96h, polychaete
	170,000		LC50, 7d, <i>Crepidula fornicata</i> (slipper limpet)
	320,000		100% mortality, 48h, midge
1,1-Dichloroethane	202,000		LC50, 7d, <i>Poecilia reticulata</i> (guppy)
1,1-Dichloroethene	<2,400		NOEC, (mortality), 48h, <i>Daphnia magna</i>
	9,000	130,000	LC50, 24-48h, <i>Daphnia magna</i>
	80,000		NOEC (mortality), 96h, sheephead minnow
	200,000	340,000	LC50, 24-96h, sheephead minnow
	250,000		LC50, 96h, inland silverside
1,2-Dichloroethane	6,927	33,646	LC50, 72h, <i>Artemia bahia</i>
	11,000	21,000	reproduction, ^b 28d, <i>Daphnia magna</i>
	42,000	72,000	growth, ^b 28d, <i>Daphnia magna</i>
	< 68,000		mortality, ^b 48h, <i>Daphnia magna</i>
	>100,000		LC50, 24-96h, <i>Gammarus fasciatus</i> (scud)
	>100,000		LC50, 24-96h, stonefly
	113,000		LC50, 96h, <i>Americamysis bahia</i> (opossum shrimp)
	186,000		LC50, 48h, Australian barnacle
	220,000	1,430,000	LC50, 24-48h, <i>Daphnia magna</i>
	200,000	400,000	mortality, ^b 15d, polychaete
	320,000		LC50, 24h, <i>Artemia bahia</i>
	400,000	900,000	LC50, 96h, polychaete

Analyte	Minimum Reported Concentration ^a (µg/L)	Maximum Reported Concentration (µg/L)	Study Description
Acetone (2-Propanone) ^a	10,000		LC50, 24-48h, <i>Daphnia magna</i>
	51,000		LC50, 24h, rotifer
	100,000		immobilization, ^b 2-24h, <i>Daphnia magna</i>
	>100,000		LC50, 12d, Northern quahog
	>100,000		EC50 (development), 48h, American oyster
	>100,000		LC50, 96h, <i>Gammarus pulex</i> (scud)
	>100,000		LC50, 96h, <i>Lumbriculus variegates</i> (oligochaete worm)
	>100,000		LC50, 96h, <i>Helisoma trivolvis</i> (ramshorn snail)
	>100,000		LC50, 96h, <i>Dugesia tigrina</i> (flatworm)
	1,000,000		reproduction, ^b 240d, Great pond snail
	1,101,000 ^c		LC50, 192h, Southern king crab
Benzene	>1,000	1,000,000	LC50, 24h, rotifer
	1,100		development, ^b 24d, Dungeness crab
	6,700	42,000	LC50, 48-96h, <i>Gammarus</i> sp.
	10,000		LC50, 48h, damselfly
	12,860		mortality, ^b 24h, yellow fever mosquito
	<13,000		mortality, ^b 48h, <i>Daphnia magna</i>
	15,000	345,000	LC50, 48-96h, <i>Daphnia pulex</i>
	16,796	21,216	LC50, 24-96h, <i>Crangon franciscorum</i> (shrimp)
	18,400		LC50, 24h, <i>Ceriodaphnia dubia</i>
	21,000	66,000	LC50, 24-48h, <i>Artemia salina</i>
	27,000	90,800	LC50, 24-96h, <i>Palaemonetes pugio</i> (shrimp)
	27,000	43,500	LC50, 24-96h, <i>Palaemonetes pugio</i> (shrimp)
	33,587		mortality, ^b 48h, <i>Daphnia magna</i>
	34,000		LC50, 48h, mayfly
	48,000		LC50, 48h, water boatman
	58,000	76,000	LC50, 24-120h, <i>Gammarus fossarum</i>
	59,600	1,130,000	LC50, 24-48h, <i>Daphnia magna</i>
	71,000		LC50, 48h, northern house mosquito
	74,000		LC50, 48h, vortex worm
	88,400	884,000	mortality, ^b 0-7d, copepod
	82,000	111,500	LC50, ≤96h, copepod
	100,000		LC50, 48h, <i>Chironomus</i>
	100,000		mortality, ^b 10d, ciliate protozoa
	108,000	>347,000	LC50, 24-96h, Dungeness crab
	111,800		mortality, ^b 0.03-1 h, American lobster
	120,000		LC50, 48h, <i>Asellus aquaticus</i> (aquatic sowbug)
	130,000		LC50, 48h, stonefly
	165,000	228,000	mortality, ^b 24-96h, Japanese littleneck clam
	190,000	225,000	LC50, 24-96h, marine bivalve
	200,000		LC50, 24-48h, yellow fever mosquito
	230,000	1,410,000	LC50, 24-120h, great pond snail
	250,000	680,000	LC50, 24-120h, <i>Asellus aquaticus</i> (aquatic sowbug)
	>320,000		LC50, 48h, leech
	>320,000		LC50, 48h, oligochaete
	356,000	390,000	LC50, 48h, <i>Daphnia cucullata</i>
	377,000		LC50, 48h, Pacific oyster
	590,000	2,550,000	LC50, 24-120h, snail
	710,000		LC50, 96h, copepod
	3,306,160	11,350,560	LC50, 24-96h, crab
Carbon disulfide	2,100		LC50, 48h, <i>Daphnia magna</i>
	45,000	94,000	LC50, 96h, bleak

Analyte	Minimum Reported Concentration ^a (µg/L)	Maximum Reported Concentration (µg/L)	Study Description
Carbon tetrachloride (tetrachloromethane)	200		LC50, 7d, <i>Dugesia japonica</i> (flatworm)
	500		abnormal growth, ^b 90 h, hydra
	1,500		EC50, abnormal growth, 7d, <i>Dugesia japonica</i> (flatworm),
	2,300		LC50, 3h, <i>Moina macrocopa</i>
	35,000	770,000	LC50, 24-48h, <i>Daphnia magna</i>
	11,100		LC50, 96h, <i>Gammarus pseudolimnaeus</i> (Scud)
	28,000	5,383,805	EC50, 24h, locomotion, immobilization, equilibrium, <i>Daphnia magna</i>
	2,153,522		LC50, 24h, <i>Artemia salina</i>
	3,520,000		development, ^b 60h, sea urchin
Chlorobenzene	1,400	22,000	EC50 (reproduction), 7-10d, <i>Ceriodaphnia dubia</i>
	<1,400		NOEC (mortality), 9-11d, <i>Daphnia magna</i>
	2,500	19,000	EC50 (reproduction), 9-14d, <i>Daphnia magna</i>
	3,890		NOEC (mortality), 7-10d, <i>Ceriodaphnia dubia</i>
	6,500	11,000	NOEC (reproduction), 9-11d, <i>Daphnia magna</i>
	7,600	47,000	LC50, 24-168h, <i>Ceriodaphnia dubia</i>
	8,600		LC50, 24-240h, <i>Daphnia magna</i>
	10,000		mortality, ^b 48h, <i>Daphnia magna</i>
	12,000	19,000	NOEC (reproduction), 7-10d, <i>Ceriodaphnia dubia</i>
	16,400		LC50, 96h, <i>Americamysis bahia</i> (opossum shrimp)
Chloroethane	na		
Chloroform (trichloromethane)	2,000	2,400	LC50, 1h, <i>Brachionus</i> sp.(rotifer)
	3,400	200,000	NOEC, 7-10d, mortality, reproduction, <i>Ceriodaphnia dubia</i>
	6,300	200,000	NOEC, 9-21d, Equilibrium, reproduction, mortality, <i>Daphnia magna</i>
	27,290	34,300	EC50, 24h, Immobilization, <i>Artemia salina</i>
	29,000	758,000	LC50, 24-216h, <i>Daphnia magna</i>
	32,000		NOEC mortality, 96h, <i>Penaeus duorarum</i> (Northern pink shrimp)
	48,000		NOEC (equilibrium), <i>Daphnia magna</i>
	54,000		NOEC, mortality, <i>Tallaperla maria</i> (stonefly)
	55,670		LC50, 48h, <i>Chironomus thummi</i>
	51,571	602,000	EC50, <i>Daphnia magna</i> , equilibrium, locomotion, immobilization, reproduction, 24h-11d, <i>Daphnia magna</i>
	81,500	134,000	LC50, 24-72h, <i>Penaeus duorarum</i> (Northern pink shrimp)
	116,680		LC50, 96h, <i>Tallaperla maria</i> (stonefly)
	120,000		near zero mortality, 24h, <i>Chironomus thummi</i>
	180,000		near zero mortality, 96h, <i>Helisoma trivolvis</i> (ramshorn snail)
	199,200		LC50, 96h, <i>Gammarus minus</i> (scud) (change in mortality of unknown significance reported at 100,000 µg/L)
	200,000		near 100% mortality, 48h, <i>Chironomus thummi</i>
	232,000		LC50, 96h, <i>Helisoma trivolvis</i> (ramshorn snail)
	235,000	368,000	LC50, 48-216h, <i>Ceriodaphnia dubia</i>
	250,000		near 100% mortality, <i>Tallaperla maria</i> (stonefly)
	300,000		near 100% mortality, 24h, <i>Helisoma trivolvis</i> (ramshorn snail)
	311,000	368,000	EC50, reproduction, 7-10d, <i>Ceriodaphnia dubia</i>
	6,500,000		mortality, ^b 25min, <i>Lumbriculus variegatus</i>
Chloromethane	270,000		LC50, 96h, inland silverside
	550,000		LC50, 96h, bluegill
cis- or trans-1,2-dichloroethene	6,785	21,329	LC50, 24h, <i>Artemia salina</i>
	140,000	165,000	LC50, 24-96h, bluegill

Analyte	Minimum Reported Concentration ^a (µg/L)	Maximum Reported Concentration (µg/L)	Study Description
Ethylbenzene	30	3,000	development and reproduction, ^b 2-9d, sponge
	425	1,907	LC50, 24-96h, <i>Crangon franciscorum</i> (shrimp)
	1,000		NOEC, 96h, <i>Americamysis bahia</i> (opossum shrimp)
	1,940		LC50, 96h, <i>Gammarus pseudolimnaeus</i> (scud)
	2,600	87,600	LC50, 24-96h, <i>Americamysis bahia</i> (opossum shrimp)
	2,700		LOEC, 96h, <i>Americamysis bahia</i> (opossum shrimp)
	6,800		mortality, ^b 48h, <i>Daphnia magna</i>
	10,200	22,100	LC50, ≤ 96h, <i>Palaemonetes pugio</i> (shrimp)
	13,000	40,000	LC50, 48-96h, Dungeness crab
	13,900	190,000	LC50, 24-48h, <i>Daphnia magna</i>
	15,370		LC50 24h <i>Artemia salina</i> brine shrimp
	16,000	40,000	LC50, ≤ 96h, copepod
	324,510		LC50, 48h, Pacific oyster
	1,030,080		development, ^b 48h, Pacific oyster
Methylene chloride	68,000		mortality, ^b 48h, <i>Daphnia magna</i>
	84,478	122,299	LC50, 24h, <i>Artemia salina</i>
	108,500		LC50, 48h, grass shrimp
	256,000		LC50, 96h, <i>Americamysis bahia</i>
	310,000	2,270,000	LC50, 24-48h, <i>Daphnia magna</i>
	500,000		mortality, ^b 2d, <i>Physa</i> sp. (pouch snail)
	1,044,639		LC50, 24h, <i>Artemia salina</i>
Naphthalene	2,020,620		LC50, 24h, rotifer
	50	470	mortality, development and reproduction, ^b 4-14d, midge
	130		development, ^b 13d, Dungeness crab
	600		mortality, ^b 48h, <i>Daphnia magna</i>
	750	4,500	mortality, 1-8 wk, sand shrimp
	850	1,280	LC50, 96h, <i>Neomysis americana</i> (opossum shrimp)
	971	2,210	LC50, 24-96h, <i>Pandalus goniurus</i> (shrimp)
	1,000	3,890	LC50, 48-96h, <i>Daphnia pulex</i>
	1,000	2,500	LC50, 96h, dragonfly
	1,000		mortality and reproduction, ^b 24h, copepod
	1,000	20,000	mortality, ^b 24h, , scud
	1,000	2,000	mortality, ^b 24h, copepod
	1,100	2,800	LC50, 8d, <i>Hemigrapsus nudus</i> (shore crab)
	1,390		LC50, 96h, shortscale eualid
	2,000	4,000	LC50, 24-96h, shrimp
	>2,000		LC50, 96h, Dungeness crab
	2,160	22,600	LC50, 24-48h, <i>Daphnia magna</i>
	2,250	3,120	LC50, 24h, blue crab
	2,350	2,600	LC50, 24-96h, <i>Palaemonetes pugio</i> (shrimp)
	2,500		LC50, 96h, <i>Penaeus azteca</i> (brown shrimp)
	2,680	3,930	LC50, 24-96h, scud
	2,700	3,070	100% mortality, 2-4d, green sea urchin
	2,810		LC50, 48h, <i>Chironomus tentans</i>
	3,780		LC50, 24h, Calanoid copepod
	3,800		LC50, 96h, <i>Nereis arenaceodentata</i>
	3,800		LC50, 96h, <i>Nereis arenaceodentata</i>
	3,930		LC50, 48h, <i>Gammarus minus</i> (scud)
	5,020		LC50, 48h, <i>Physa gyrina</i> (pouch snail)
	10,641		LC50, 24h, <i>Artemia salina</i> , brine shrimp
	12,200	20,700	LC50, 48h, <i>Tanytarsus dissimilis</i> (midge)
	13,000	13,900	LC50, 24-48h, <i>Chironomus attenuatus</i> (midge)

Analyte	Minimum Reported Concentration ^a (µg/L)	Maximum Reported Concentration (µg/L)	Study Description
Naphthalene, cont'd	16,690		mortality, ^b 96h, <i>Uca pugnator</i> (fiddler crab)
	18,537		mortality and reproduction, ^b 10d, copepod
	36,406	43,713	LC50 and development, 24-48h, protozoa
	57,000	74,000	LC50, 24-96h, marine bivalve
	67,800		LC50, 96h, calanoid copepod
	110,000	194,000	LC50 and development, 48h, Pacific oyster
Tetrachloroethene	331	18,241	LC50, 24h, <i>Artemia salina</i>
	400		NOEC (reproduction), 21d, <i>Daphnia magna</i>
	510	1,100	growth, ^b 28d, <i>Daphnia magna</i>
	510	1,100	reproduction, ^b 28d, <i>Daphnia magna</i>
	900		EC50, (growth), 7d, flatworm
	1,400		LC50, 7d, flatworm
	1,300		LC50, 96h, grass shrimp
	1,300		LC50, 96h, <i>Nereis arenaceodentata</i>
	1,800		LC50, 3h, water flea
	2,500		NOEC (mortality), 24h, grass shrimp
	3,600		LC50, 96h, stonefly
	18,850		mortality, ^b 24h, grass shrimp
	3,500		LC50, 48h, Australian barnacle
	9,100	28,600	LC50, 96h, <i>Gammarus</i> sp. (scud)
	7,000	54,600	LC50, 24-48h, midge
	9,100		LC50, 48h, <i>Daphnia magna</i>
	10,000		mortality, ^b 48h, <i>Daphnia magna</i>
	10,200		LC50, 96h, opossum shrimp
	13,200		LC50, 96h, calanoid copepod
	17,400		LC50, 96h, sand shrimp
	21,000	60,000	100% mortality, 24h, <i>Gammarus</i> sp. (scud)
	93,400		LC50, 96h, pond snail
Toluene (methylbenzene)	1,000	2,000	NOEC (reproduction, equilibrium), 21d, <i>Daphnia magna</i>
	2,830	10,400	EC50, 24-96h, development, <i>Lumbriculus variegatus</i> (oligochaete worm)
	5,600	64,800	NOEC (mortality), 24-48h, <i>Chironomus thummi</i>
	7,600		LC50, 24h, <i>Ceriodaphnia dubia</i>
	9,500	38,100	LC50, 24-96h, <i>Palaemonetes pugio</i> (daggerblade shrimp)
	14,700	23,920	LC50, 24-96h, <i>Eualus</i> sp. (shrimp)
	23,500		LC50, 8d, <i>Hemigrapsus nudus</i> (shore crab),
	24,200	74,200	LC50, 96h, <i>Nitocra spinipes</i> (harpacticoid copepod)
	28,000		LC50, 96h, <i>Cancer magister</i> (Dungeness crab)
	33,000	61,200	LC50, 24h, <i>Artemia</i> sp.
	38,900		NOEC (mortality), 96h, <i>Physa heterostrophica</i> (pond snail)
	47,000	108,660	LC50, 48h, <i>Chironomus thummi</i>
	53,000	93,000	NOEC (equilibrium), 24h, <i>Daphnia magna</i>
	55,600		LC50, 96h, <i>Physa heterostrophica</i> (pond snail)
	58,000		LC50, 96h, <i>Gammarus minus</i> (scud)
	86,300	470,000	LC50, 24-48h, <i>Daphnia magna</i>
	92,140		Locomotion and development, ^b 5-14d, Scyphistomae (common jellyfish)
	113,000	552,600	LC50, 24h, <i>Brachionus</i> sp. (rotifer)
	172,000		LC50, 48h, <i>Crassostrea gigas</i> (Pacific oyster)
	225,000	250,000	LC50, 24-96h, <i>Katelsia opima</i> (marine bivalve)
	447,000		LC50, 96h, <i>Diaptomus forbesi</i> (calanoid copepod)
	500,000		EC100, equilibrium, 24h, <i>Daphnia magna</i>

Analyte	Minimum Reported Concentration ^a (µg/L)	Maximum Reported Concentration (µg/L)	Study Description
Toluene (methylbenzene), cont'd	790,000		LC50, 96h, chironomid
	1,047,000		EC50 (development), 48h, <i>Crassostrea gigas</i> (Pacific oyster)
	1,100,000		LC50, 96h, <i>Melanoides tuberculata</i> (snail)
Trichloroethene	1,700		LC50 and growth, 7d, flatworm
	2,200		mortality, ^b 48h, <i>Daphnia magna</i>
	2,300		LC50, 3h, water flea
	2,300	8,000	LOEC and NOEC (growth), 21d, <i>Daphnia magna</i>
	18,000	100,000	LC50, 24-48h, <i>Daphnia magna</i>
	14,000	27,000	LC50, 96h, <i>Americamysis bahia</i> (opossum shrimp)
	20,000		LC50, 48h, Australian barnacle
	24,000		LC50, 48h, <i>Gammarus pulex</i> (scud)
	30,000		LC50, 48h, <i>Asellus aquaticus</i> (aquatic sowbug)
	39,000	51,000	LC50, 48h, <i>Daphnia pulex</i>
	42,000		LC50, 48h, mayfly
	42,000		LC50, 48h, vortex worm
	48,000		LC50, 24-48h, yellow fever mosquito
	49,000		LC50, 48h, damselfly
	55,000		LC50, 48h, northern house mosquito
	56,000		LC50, 24-48h, great pond snail
	56,000	58,000	LC50, 48h, <i>Daphnia cucullata</i>
	64,000		LC50, 48h, <i>Chironomus</i> (midge)
	70,000		LC50, 48h, stonefly
	75,000		LC50, 48h, hydra
	75,000		LC50, 48h, leech
	110,000		LC50, 48h, water boatman
	132,000		LC50, 48h, oligochaete
Vinyl chloride (chloroethene)	128,000		NOEC (mortality), 96h, <i>Brachydanio rerio</i> (zebrafish)
	388,000		100% mortality, 10d, Northern pike
Xylene	7,400	14,000	LC50, 24-96h, grass shrimp
	7,920		mortality, ^b 24h, yellow fever mosquito
	20,000	40,000	LOEC and NOEC (reproduction), 48-2d, rotifer
	53,000	184,000	LC50, 24-120h, <i>Gammarus fossarum</i> (scud)
	87582		LC50, 24h, fairy shrimp
	99,000		EC50, reproduction, 2d, rotifer
	99,500		LC50, 24h, calanoid copepod
	150,000	<1,000,000	LC50, 24h, <i>Daphnia magna</i>
	190,000	240,000	LC50, 24-96h, marine bivalve
	190,000	270,000	LC50, 24-120h, <i>Asellus aquaticus</i> (aquatic sowbug)
	194,273		LC50, 24h, <i>Artemia salina</i>
	350,000	2,070,000	LC50, 24-96h, snail

Bold numbers represent the lowest concentration for each chemical reported in ECOTOX. These concentrations were conservatively selected as RBCs and are the basis of the ACGs identified in Table C-2

na-not available in ECOTOX

^a If only one concentration was reported in ECOTOX for a particular endpoint and species, it is presented as the minimum concentration

^b The ECOTOX database did not specify the effect level (e.g., LC50 or NOEC)

^c Additional higher concentrations were reported in ECOTOX

The ACG for each VOC is equivalent to the RBC derived as described above. These ACGs are compared to ARI's RLs using EPA Method 8260B in Table C-2. A complete list of ARI's MDLs and RLs is presented in Table C-3. For all of the VOCs in Table C-2, the RL is at least two orders of magnitude lower than the derived ACGs. Thus, the VOC method is sufficiently sensitive to meet the ACGs in Table C-2.

Table C-2. ACGs compared to RLs

Analyte	RL (µg/L)	ACG (µg/L)
1,1,1-Trichloroethane	0.2	1,300
1,1,2-Trichloroethane	0.2	1,000
1,1-Dichloroethane	0.2	202,000
1,1-Dichloroethene	0.2	< 2,400
1,2-Dichloroethane	0.2	6,927
Acetone (2-propanone)	2.0	10,000
Benzene	0.2	> 1,000
Carbon disulfide	0.2	2,100
Carbon tetrachloride (tetrachloromethane)	0.2	200
Chlorobenzene	0.2	1,400
Chloroethane	0.2	na
Chloroform (trichloromethane)	0.2	2,000
Chloromethane	0.2	270,000 ^a
cis- or trans-1,2-dichloroethene	0.2	6,785
Ethylbenzene	0.2	30
m,p,-Xylene (xylene)	0.4	7,400 ^b
Methylene chloride	0.3	68,000
Naphthalene	0.5	50
o-Xylene (xylene)	0.2	7,400 ^b
Tetrachloroethene	0.2	331
Toluene (methylbenzene)	0.2	1000
Trichloroethene	1.0	1,700
Vinyl chloride (chloroethene)	0.2	128,000

^a Value for fish species because no value was available for invertebrate species

^b RBC for xylene used because no toxicological data were available for these xylene isomers

Table C-3. List of MDLs and RLs for entire list of VOCs as reported by ARI using EPA Method 8260B

Analyte	MDL (µg/L)	RL (µg/L)
1,1,1,2-Tetrachloroethane	0.033	0.2
1,1,1-Trichloroethane	0.044	0.2
1,1,2,2-Tetrachloroethane	0.089	0.2
1,1,2-Trichloro-1,2,2-trifluoroethane	0.030	0.2
1,1,2-Trichloroethane	0.059	0.2
1,1-Dichloroethane	0.071	0.2
1,1-Dichloroethene	0.047	0.2
1,1-Dichloropropene	0.060	0.5
1,2,3-Trichlorobenzene	0.121	0.5
1,2,3-Trichloropropane	0.193	0.5
1,2,4-Trichlorobenzene	0.119	0.5
1,2,4-Trimethylbenzene	0.037	0.2
1,2-Dibromo-3-chloropropane	0.168	0.5
1,2-Dibromoethane	0.107	0.2
1,2-Dichlorobenzene	0.041	0.2
1,2-Dichloroethane	0.097	0.2
1,2-Dichloropropane	0.042	0.2
1,3,5-Trimethylbenzene	0.066	0.2
1,3-Dichlorobenzene	0.058	0.2
1,3-Dichloropropane	0.083	0.2
1,4-Dichlorobenzene	0.053	0.2
2,2-Dichloropropane	0.088	0.2
2-Butanone	0.657	1.0
2-Chloroethyl vinyl ether	0.063	0.5
2-Chlorotoluene	0.058	0.2
2-Hexanone	0.384	1.0
4-Chlorotoluene	0.017	0.2
4-Isopropyl toluene	0.098	0.2
4-Methyl-2-pentanone	0.400	1.0
Acetone (2 propanone)	1.080	2.0
Acrolein	0.319	5.0
Acrylonitrile	0.201	0.2
Benzene	0.041	0.2
Bromobenzene	0.036	0.2
Bromochloromethane	0.077	0.2
Bromodichloromethane	0.049	0.2
Bromoethane	0.072	0.2
Bromoform	0.100	0.2

Analyte	MDL (µg/L)	RL (µg/L)
Bromomethane	0.078	0.2
Carbon disulfide	0.071	0.2
Carbon tetrachloride (tetrachloromethane)	0.042	0.2
Chlorobenzene	0.041	0.2
Chlorodibromomethane	0.047	0.2
Chloroethane	0.107	0.2
Chloroform (trichloromethane)	0.047	0.2
Chloromethane	0.045	0.2
cis-1,2-Dichloroethene	0.037	0.2
cis-1,3-Dichloropropene	0.061	0.2
Dibromomethane	0.077	0.2
Dichlorodifluoromethane	0.196	0.2
Ethylbenzene	0.065	0.2
Hexachloro-1,3-butadiene	0.185	0.5
Iodomethane	0.081	0.2
Isopropyl benzene	0.047	0.2
m,p-Xylene	0.078	0.4
Methylene chloride	0.011	0.3
Methyl-t-butyl ether (MTBE)	0.056	0.2
Naphthalene	0.093	0.5
n-Butylbenzene	0.088	0.2
n-Propyl benzene	0.074	0.2
o-Xylene	0.055	0.2
s-Butylbenzene	0.074	0.2
Styrene	0.069	0.2
t-Butylbenzene	0.054	0.2
Tetrachloroethene	0.062	0.2
Toluene (methylbenzene)	0.048	0.2
trans-1,2-Dichloroethene	0.114	0.2
trans-1,3-Dichloropropene	0.054	0.2
trans-1,4-Dichloro-2-butene	0.164	0.2
Trichloroethene	0.071	1.0
Trichlorofluoromethane	0.054	0.2
Vinyl acetate	0.093	0.2
Vinyl chloride (chloroethene)	0.056	0.2

MDL studies are performed in accordance with 40 CFR Part 136, Appendix B, using six degrees of freedom. The MDLs in this table reflect the most recent MDL study conducted by ARI.

MDLs are statistically derived values, and are a measure of short-term precision. True detection at the statistical MDL may not be achievable for all analytes and methods.

Reporting Limit (RL) is defined as the lowest value at which qualitative detection of a given analyte is reported. The RL is based on the MDL, method efficiency, and analyte response. The RL will, at a minimum, equal the MDL (rounded). The RL may exceed the MDL for certain analytes.

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